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AIR POLLUTION CONTROL ASSOCIATION

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1960 Miss Cleaner Air Week and Mr. J. E. Tobey of Cincinnati. *(See page 491.)*

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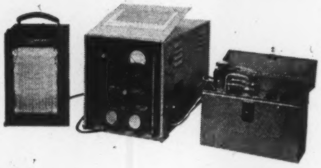

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APCA ABSTRACTS

Vol. VII, No. 5 October 1961

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GENERAL ASPECTS OF AIR POLLUTION

3867. Air Pollution. Past, Present, and Future. S. R. CRAXFORD. *Inst. Petrol. Rev.* (London) **15,** 133–9 (May 1961).

Air pollution data for the past 8 yrs. have been analyzed in order to predict future trends. The data indicate that emissions from high chimneys make relatively little contribution to pollution near the ground, which is determined by emissions from the lower chimneys, whether domestic for smoke, or industrial and domestic for sulfur dioxide. Only yearly average values of concentrations of pollutants have been considered. For given meteorological conditions the concentrations of pollutants observed will be proportional to the amounts emitted in the neighborhood concerned, and that a change in the proportion of high- to low-level emissions will affect concentrations during a smog in the same way as it affects the yearly average concentrations. Improvements in the yearly average should lead to corresponding improvements in time of smog.

3868. Clean Air and Smokeless Fuel; A Small-Scale Inquiry. J. GORMAN. *Med. Officer* (London) **100,** 211–12 (Sept. 26, 1958).

With a view to obtaining some measure of local public reaction to the program against air pollution, particularly to the use of smokeless fuel, a short questionnaire was presented to each householder in a new Council Estate of some 250 houses situated on the outskirts of the built-up area of the city. The houses involved were all provided with modern approved grates. Of the 249 forms issued, 142 were returned. The results of the survey are indicated graphically in Figure 1 in the text, and show that 83% still used ordinary bituminous coal as a main fuel. In reply to the question of why a smokeless fuel was not used, it was felt that the reasons given in the 113 replies did not indicate indifference but rather attitudes which represented individual experience. The supply of smokeless fuel varies between coke, which is readily available but of varying quality, and the proprietary fuels which are sometimes available and sometimes necessitate an indefinite wait. Also, regardless of how freely available these fuels are centrally, the distribution system often does not encourage the householder to ask for and obtain the small quantities which he often desires. Smokeless fuel requires a certain amount of instruction in its use, and gas ignition is probably essential to starting a fire with any of the existing smokeless fuels if the regulations of a smoke-controlled area are to be observed. The public still needs to be convinced that even if smokeless fuel costs more it may not be as expensive as it seems because of its superior heat output and absence of pollution damage. It was concluded that this small scale inquiry suggests that the public is to a limited extent "clean air conscious" but that a planned coordinated approach must be made to every householder if smoke control is to be accepted voluntarily as well as through legislation. (LC)

3869. Formation of Air Pollutants. G. GOULD. *Power* **104,** 86–8 (Aug. 1960).

Different types of equipment, operating methods, boiler and furnace designs, and load demands, influence in various ways the quantities and characteristics of air pollutants which are formed. High heat-release rates are generally accompanied by excessive fly ash, cinder carry-over and sometimes smoke. Plume opacity increases as particle size decreases. Removal of + 20μ particles has little or no effect on the appearance of a plume. Even with good combustion, opacity of plume may exceed a No. 2 Ringelmann smoke shade. The LAPCD testing program showed an average of 0.14 lb. dust/1000 lb. gas. Tests have shown as little as 3 ppm. SO_3 in flue gases produces a visible plume, 15 ppm. a conspicuous one, and normal particulates opacity is increased 50%. In gas-fired equipment particulate emission is not likely to be of consequence. If a nitrogen oxide hydrocarbon smog problem is involved quantities of nitrogen oxide which may be produced could be a matter of concern.

3870. Evaluating Air Pollution Problems. Acceptable Equipment and Procedures. R. O. MCCALDIN. *Arch. Environmental Health* **2,** 52–7 (Mar. 1961).

Availability and reliability of equipment, cost of operation, and skill required for satisfactory results are factors to be considered in equipment choice. This article deals with some of the more widely used devices and techniques for measuring specific types of air pollutants, and describes some of the more common equipment used in making environmental air quality determinations. In addition to these determinations a complete air pollution investigation should include an evaluation of emission sources, a study of meteorological conditions, and evaluation of the effects produced by air pollutants. With this information the air quality improvements which are necessary for a satisfactory environment can be determined.

3871. The Office for Industrial Dust Control (Foundries and Steel Works) and Its Significance. E. STIEF. **Giessereitechnik* (Berlin) **5,** 328–30 (Nov. 1959).

In future the Office for Industrial Dust Control (Foundries and Steel Works) is to be responsible for dust control and ventilation in all foundries. It will collaborate, both in administration and in research, with the VVB Giessereien, the Central Office for Silicosis Research at Berlin, and the Central Research Institute for Ore Mining at Eisleben. (LC)

3872. Air Pollution Report. *Cincinnati J. Med.* **40,** 172–4 (Apr. 1959).

After an examination of the available evidence and following their conviction that today's increased pollution of urban atmospheres constitutes a potential health hazard, the members of the Committee on Preventive Medicine of the Academy of Medicine of Cincinnati made the following recommendations. They urged the establishment of an air pollution control program to incorporate both regulation and monitoring services starting with items such as the sulfur gases, and total oxidants or ozone. They recommended that the Council of the Academy authorize its president to appoint a committee of three members from the Academy who should be properly qualified in all matters pertaining to the community health hazards of air pollution to consult with the Council of the City of Cincinnati in matters on air pollution. And that the above-named committee on air pollution be directed to consider (a) the immediate institution of a properly supervised system of continuously-acting monitors of air pollution to determine the varying types of air pollution in the community atmosphere, and (b) the acceptance of a standard for levels of concentration of recognized air pollution, the presence of which would be indicative of the approach of danger to the public health. The recommendation for maximum allowable concentration for ozone or total oxidants was 0.2 mg./m.^{3} or 0.1 p.p.m., with a limit for daily average of 0.10 mg./m.^{3} or 0.05 p.p.m. In the absence of an established maximum allowable concentration in outside air for sulfur dioxide and sulfuric acid mist, they recommended: for SO_2, 5.0 mg./m.^{3} with exposures limited to 8 hours, or 0.2 p.p.m.; for H_2SO_4 mists (not a gas), 0.3 mg./m.^{3} for a single day average. These figures should both be subjected to change as further evidence is obtained. The Council also agreed to draft an appropriate resolution for state control of air pollution and submit it to the Ohio State Medical Association, and then through channels to the Ohio General Assembly. It is the consensus of the Committee that auto exhaust gases offer a potential health hazard in this urban community which should be closely watched and studied. Following several other recommendations, it was voted that the opinion of the Academy of Medicine of Cincinnati concerning the control of air pollution in Cincinnati be made known to the public through press releases. And that it was their belief that currently there is no serious health hazard existing in the Cincinnati air. (LC)

SOURCE, POLLUTANTS, CONTROL OF AIR POLLUTION

3873. Air Pollution from Automobile Exhaust. W. L. FAITH. *J. Occupational Med.* **2,** 439–41 (Sept. 1960).

About 5 to 7% of the gasoline fed to an internal-combustion

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* Shows new journals added in this issue. See list at end showing addresses for these, also journals added in the September issue.

APCA ABSTRACTS

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engine does not burn completely and atmospheric pollution results. Obvious pollutants in motor vehicle exhaust are smoke, carbon monoxide, nitrogen oxides, lead salts, aldehydes, and perhaps sulfur dioxide. Less obvious pollutants are various hydrocarbons from unburned gasoline and its cracked products and the variety of gasoline additives that may remain unburned or partially burned in the exhaust gases. During the past year work on the smog effects of auto exhausts has been carried on in the smog chamber at Stanford Research Institute. These experiments dealt with the atmospheric reactions between oxides of nitrogen and various types of hydrocarbons that might be found in exhaust gases, in the presence of simulated sunlight. Tentative conclusions drawn by the Air Pollution Foundation from this study are stated to be: (1) The probable eye irritants in photochemical smog are formaldehyde and acrolein (peroxyacetyl nitrate may also contribute to eye irritation). (2) These aldehydes are formed only from olefinic hydrocarbons. Similarly, the only organic compounds involved in photochemical aerosol formation appear to be olefins. (3) Paraffinic and aromatic hydrocarbons are not involved to any appreciable degree in the production of smog manifestations. The only exception is the comparatively slow photo-oxidation of certain branched-chain paraffins to produce ozone. From a practical standpoint, this reaction is probably unimportant. (4) Accordingly, Los Angeles-type smog can be eliminated by drastic curtailment of atmospheric olefins. It may also be possible to eliminate smog by control of the nitrogen oxides in exhaust gases. Studies of this possibility are presently under way. (LC)

3874. Rating of Dust Collectors According to Dust Settling Velocities. W. C. L. HEMEON, G. F. HAINES, JR., and S. D. PUNTURERI. *J. Air Poll. Control Assoc.* **11,** 264–7 (June 1961).

This article describes the apparatus and a technique to measure the inertial quality of any dust for determination of its collectibility in various types of equipment where inertial forces predominate. It measures the distribution of settling velocities analogous to the phrase "distribution of particle size," which might be described alternately as the distribution of particle inertia, and it can measure the collectibility of the elements of a dust mixture. A portable elutriator was developed for use on the dust-laden air stream. It consists of a number of horizontal trays through which the dusty air is drawn, then to a filter, a flowmeter, and an air pump. The purpose of multiple channels is to produce a condition of streamline motion by a reduction of the diam. factor in the Reynolds number. Dust particles settle to the floor at locations determined by the settling velocity of the gas stream. Weights of dust settled out in various segments along the length of a channel are determined along with that collected in the after filter. Data, with cumulative weight per cent of sediment are shown in figure 3.

3875. Carcinogens in the Human Environment. W. C. HUEPER. *A.M.A. Arch. Pathol.* **71,** 237–67 (Mar. 1961).

A group of man-made environmental carcinogens, composed of a rapidly increasing number and variety of chemical and physical agents, which are the products of the modern industrial development, are listed in an extensive table in the text. These substances include: arsenic; asbestos; chromium; nickel; aromatic amines; benzol; isopropyl oil; mustard gas; anthracene; coal tar and pitch; creosote; industrial, commercial and domestic soots; mineral oils; petroleum asphalt, bitumen coke, pitch and carbon; paraffin and petroleum waxes; aliphatic and aromatic epoxides; B-propiolactone; carbamates; chlorinated hydrocarbons; estrogens (natural and synthetic); diethylene glycol; 8-hydroxyquinoline; surfactants-detergents; tannic acid; thiourea, etc.; thermic and oxidation products of oils and fats of vegetable and animal derivation; water-insoluble carbon and silicon macromolecular polymers; water-soluble macromolecular polymers; beryllium; cobalt; selenium and iron. Each of these compounds are discussed, in a modified outline form, as to site of cancer, exposure stigmata, compounds of economic importance, operations and products with contact by the agent, occupational groups with exposure, and non-occupational groups. The second half of the information given here deals with characteristics of environmental carcinogens.

The paper is to be concluded in a later issue. **Ibid.** 355–80 (Apr. 1961). This is a continuation of the article from the March issue of this journal and consists of Section III, "Sources of Potential Environmental Cancer Hazards to the General Population." In table 3 on the "Environmental Pollutants and Consumer Goods as Potential Sources of Environmental Cancer Hazards," item III lists in some detail the "Domestic and General Air Pollutants." Table 11 gives a "Rough Estimate of the Polycyclic Hydrocarbons in a Coffee Soot produced by the Direct Application of Heat." Of the ten substances listed, benz(a)anthracene with 16 μg./kg. was present in the smallest amount and chrysene with 543 μg./kg. the largest, while benzo(e)pyrene was found at a level of 187 μg./kg. and benzo(a)pyrene at 200 μg./kg. There is a bibliography of 303 items. (LC)

3876. [New Dust Measuring Apparatus for Rapid Determination of Dust Concentration and Particle Size Distribution.] Neues Staubmessgerät zur Schnellbestimmung der Staubkonzentration und der Kornverteilung. W. KAST. *Staub* (Düsseldorf) **21,** 215–23 (Apr. 1961).

A new measuring apparatus is described which makes possible precipitation of the dust during collection as a function of particle size, and hence direct determination of the particle size distribution. The main element of the apparatus is a spiral channel rotating at a fixed number of revolutions, on the walls of which the dust is deposited on thin foils. After simple gravimetric evaluation the most important values for characterization of a dust are available; concentration in mg./m.^{3} particle size distribution of the individual mineral components after incineration. Comparisons with traditional apparatus and methods of measurement have shown good agreement in general (English summary cond.)

3877. Control of Fume from Electric Melting Furnaces. I. R. T. PRING. *Air Cond. Heat. & Vent.* **58,** 45–50 (Jan. 1961).

Recently public concern and consequent enactment of air pollution code restrictions have focused attention on the electric steel melting furnace as a common source of air pollutants. The extremely fine fume and dust particles escaping with the gases will range in concentration from 0.25 to 3.5 grains/standard ft.^{3} and, in quantity, from 4 to 30 lb./ton of metal poured. In a cold change furnace, the lowest particle size and solids emission rate are associated with clean scrap and low melting rates. Tables 1, 2, 3, and 4 contain data on the composition of the charge and discharge from electric furnaces. Solid contaminants from the arc furnace melting of steel are characterized by extremely fine particle size. A summary of the published data on particle size of electric steel furnace fume is shown in table 5. **Ibid. II.** 121–5 (Feb. 1961). Of existing electric steel melting furnace fume control systems installed to meet provisions of air pollution regulations, the majority use roof-mounted furnace hoods in conjunction with mechanically shaken, tubular cloth filters. There is a noticeable trend toward furnace shell evacuation, particularly for larger furnaces, coupled with water spray gas cooling and cloth filtration. Silicone treated Fiber glass filter bags cleaned by reverse air flow appear feasible. The evaluation of the many electric steel furnace fume control systems installed in the past 8 yrs., has removed the uncertainties from the design and sizing of fume control equipment for electric furnace shops.

3878. Vermiculite in the Absorption of Gases, Vapors, and Fumes. S. R. RABSON. *Ind. Chemist* (London) **37,** 219–20 (May 1961).

In many processes the need arises for the extraction of 1 or more components of a gaseous mixture by chemical or physical absorption in a suitable reagent. The use of exfoliated vermiculite impregnated with suitable reagent is suggested as a means of absorbing gases in low concentrations. The application in absorption processes depends on a completely different procedure which utilizes to the max. extent the available surface area of the vermiculite and also the liquid storage capacity of the material. There are obvious difficulties attendant on the use of impregnated vermiculite when applied to the absorption of large or concentrated quantities of gaseous constituents. Its use appears to be of max. advantage in scrubbing operations where low concentrations of gaseous contaminants require to be removed, e.g., as a final purification stage to remove residual contamination products escaping from conventional scrubbing and absorption processes.

3879. Electronic Air Cleaners and Their Applications. W. A. SMITH. *Air Cond. Heat. & Vent.* **58**, 57–60 (July 1961).

In a given installation higher efficiencies can be had by reducing the air velocity moving through the electronic air cleaner. The washing equipment supplied with the cleaner contributes to the system efficiency. A moving manifold provides better washing than a stationary manifold. Electronic air cleaners can be installed alone, can be used with different types of prefilters, and can be incorporated into cost saving air recovery systems. This article discusses electronic air cleaners and these various applications, also maintenance techniques. Typical air recovery applications are shown.

3880. Design of Interference Filters for the Observation of Infrared Emission from Atmospheric Carbon Dioxide by an Earth Satellite. S. D. SMITH. *Quart. J. Meteorol. Soc.* (London) **87**, 431–4 (July 1961).

Detailed proposals are made for the design of a high order type interference filter in which the transmission bands of the filter are exactly matched to 15 lines of the R-branch of the CO_2 spectrum near 15μ. The striking energy advantages of such an interferometer are discussed and it is shown that use of an optically worked high-index germanium spacer leads to a further considerable increase in light grasp. It is concluded that technical problems are not severe and a calculation of the energy that can be collected by the proposed system suggests that a detector of area 9 mm.^{2} with a noise equivalent power of 10^{-10} w., comparable with a standard Golay cell, can provide adequate sensitivity. (Author's summary cond.)

3881. Effects of High Volatile Fuel on Incinerator Effluents. R. L. STENBURG, R. P. HANGEBRAUCK, D. J. VON LEHMDEN, and A. H. ROSE, JR. *J. Air Poll. Control Assoc.* **11**, 376–83 (Aug. 1961).

Tests demonstrate the difficulty of burning a high volatile solid waste material without making appreciable contributions to atmospheric pollution. The extent to which operational factors affect emissions of different pollutants is emphasized by the wide range of results obtained. It is concluded that minimization of pollutants cannot be affected by proper incinerator design alone but must depend on a combination of good design and proper operational procedures. Reduction of over-all emissions to a min. will require that optimum combustion conditions be maintained by controlling all operational factors within fairly close limits. Optimum combustion conditions would imply a temperature range of 1800 to 2000°F. in the secondary chamber, the use of a relatively low proportion, 15–20%, of underfire air and the charging of fuel continuously or in small batches as proposed to large batch charges.

3882. Air Pollution—Some Chemical and Physical Aspects of Its Effects on Living Material. E. T. WILKINS. In: The Effects of Air Pollution on Living Material. Symposia of Biology, **No. 8,** 71–80. London. The Institute of Biology, 1959.

Many regulatory acts to control air pollution have been instituted over the years beginning with the Alkali, etc., Works Regulation Act of 1863 which, after many amendments, is currently in operation. The Clean Air Act began in 1956. Since 1928 a cooperative project has been in operation to carry out research into the amount, nature, and prevention of air pollution, and routine measurements of deposited matter, smoke, and sulfur dioxide are made on a continuing basis. At the present time the use of coal has increased to about 200 million tons, with an additional 20 million tons of oil. Present emissions of dust, smoke, and sulfur dioxide resulting from the use of these fuels have been estimated at about 0.8, 2.0, and 5.0 million tons a year respectively. Table 1 in the text shows that the air of cities and industrial areas, in which a large proportion of the population lives, may provide about 10 times as much deposited matter plus 10 times as much sulfur dioxide plus 50 times as much smoke, as that of the countryside. Air contaminants from motor vehicle exhausts, are also a major problem. A short table is given in the text showing approximate composition of motor vehicle exhaust gases and toxic limits of concentration for 8 hours of exposure. Also discussed briefly are the smog studies of December 1952, 1955–56, and 1957–58. The author states that another possibility which arises from the theory that the irritation of the lungs by atmospheric pollution is due to acid gases or particles, is that of giving relief to chronic bronchitics and other susceptible persons by neutralizing the acidity with carefully controlled amounts of ammonia gas. **Ibid. The Effect of Air Pollution on Plant Growth.** J. K. BLEASDALE. 81–7.—Among the situations causing widespread injury to plants, are mentioned: the oxidized hydrocarbons in Los Angeles smog; hydrogen fluoride produced by aluminum works or glazing processes; and sulfur dioxide produced by smelters or smoldering slag heaps. In Britain the most widespread and economically important air pollutant is coal smoke, containing sulfur dioxide, and with which this paper is primarily concerned. The plant environment is affected in three ways by presence of coal smoke: by a reduction in the amount of light available; by alteration of soil conditions; and by contamination of the air by foreign gases. Smoke haze can reduce the light available to the plant for photosynthesis and thereby reduce its growth rate. This is most serious during winter months when light intensities are naturally low and pollution is at its highest. Summer-growing annuals and perennials, and deciduous shrubs and trees, are therefore more suited for growth in such areas than are species which go through the winter in a non-dormant state. Rain falling in or near industrial areas dissolves the predominantly acidic pollution gases from the air and leaches bases from the soil. To counterbalance this, farmers must use heavy applications of lime on the soil. Sulfur dioxide in the air in concentrations of 0.5 p.p.m. will produce leaf scorch in many species. It has been inferred from earlier experimental studies that sulfur dioxide is not a systemic poison. Other authors have concluded that the gas is without effect on growth of plants unless leaf scorch damage occurs. The author found, in earlier work, that the growth of Aberystwyth S23 rye grass was greatly reduced by treatment with the air polluted by coal smoke although no leaf scorch occurred. He postulates in some detail that sulfur dioxide in the air can interfere with the balance of sulphydryl radicals in the cells but that definite experimental proof of the theory is lacking. Another important effect of coal smoke and sulfur dioxide on plants is the increase in the rate of leaf senescence. Most important of all is the great economic loss to farmers. **Ibid. The Effects of Atmospheric Pollution on Man.** P. J. LAWTHER. 89–93.—The literature on air pollution reflects many opinions and results of bewildering diversity and contradiction. Attempts to reconcile these findings, which are usually supported by adequate scientific data, often lead to the conclusion that the apparent conflicts are explained by some common fallacies revealed by later experiments. A tentative classification of the proven or suspected effects of the varieties of air pollution is possible in the light of recent work and many seemingly paradoxical findings settle comfortably into this scheme. Air pollution accompanied by fog has become known as smog. It is unfortunate that the term smog implies that it is a definite physico-chemical entity. The common assumption, also, that smog is synonymous with serious air pollution is wholly erroneous. The way in which acute pollution kills is not known with certainty but it may well be that its action is nonspecific since it would appear that persons who succumb are primarily those with respiratory or circulatory inadequacy who are unable to withstand the added strain of the pulmonary irritation. It has been noted clinically that persons with chronic bronchitis show signs of bronchospasm during episodes. Use of simple epidemiological field techniques has demonstrated convincingly the close relationship between the worsened clinical conditions of patients with chronic bronchitis and these periods of increased pollution. The chronic pollution levels of industrial cities are believed to produce harmful effects which are relatively unknown except as statistical studies have shown them to be suspect as an etiological factor in production of chronic bronchitis and lung cancer. Pollution of the air by exhaust products from motor vehicles, railway locomotives, and other special sources constitutes another special problem which is receiving urgent attention. In answer to questions following the paper, the author stated that the diagnosis of chronic bronchitis, as it is used in Great Britain, certainly exists in North America but it is without doubt much less common and that the picture is complicated by different clinical usage and fashion both in teaching and in the filling-in of death certificates. Regarding the deaths of a considerable number of prize-winning animals at the Smithfield Show during a pollution episode in December 1957, it would appear possible that the ammonia from excreted matter saved the pigs and sheep. The cattle probably died because they were respiratory cripples due to their obesity. **Ibid. Fluorosis in Farm Animals.** R. ALLCROFT. 95–102.—[A review of the total Symposium was reported in the April issue, abstract no. 3034.] Chronic fluorine poisoning, or fluorosis, occurs in many parts of the world as a result of the high fluorine content of rock phosphate deposits, volcanic soils, and water supplies, while addition of ground rock phosphate and other fluorine-containing minerals as supplements to livestock rations has at times resulted in severe outbreaks. In Great Britain fluorosis occurs almost exclusively in animals in industrial areas and arises from air contamination of food plants by the emission of fluorine-containing dusts and gases from industrial plants. The reason for the apparently increased incidence of fluorosis during the last 20 years can be attributed to the greater use of home-grown feed stuffs, the increasing number of self-contained herds, and the expansion of industry over the same period. The toxicity of ingested fluorine depends on the length of time over which an abnormal intake occurs, the skeletal storage, age and species of the animal, physiological stresses, and the effectiveness of the defense mechanism. It is also related to solubility or availability of the fluorine compound. Sodium fluoride and sodium fluosilicate are more toxic than calcium fluoride, rock phosphate, and cryolite. Present evidence indicates the order of decreasing susceptibility of farm animals to fluorosis is calves, dairy cows, beef cattle, sheep, horses, pigs, and poultry. Feeding trials with rock phosphate as the source of fluorine have shown that poultry can tolerate a higher intake than pigs, sheep, and cattle. Pigs and poultry are usually less affected by fluorine both because of the differences in management between them and ruminants and because of their much shorter economic life span. In cattle, abnormalities of teeth and bones, with the latter resulting in various degree of lameness, are characteristic of fluorine poisoning. Various other symptoms, such as elongated hooves, diarrhea, anemia, lowered milk yield, and reduced fertility are often attributed to fluorosis but are not specific and are probably due to secondary conditions. (LC)

ATMOSPHERIC PHENOMENA, DISPERSION, EMISSION

3883. Basic Concepts Concerning Cutoff Glass Filters Used in Radiation Measurements. A. K. ÅNGSTRÖM and A. J. DRUMMOND. *J. Meteorol.* **18,** 360–7 (June 1961).

In radiation meteorology accurate filter measurements are of importance, particularly for the determination of the parameters of atmospheric transmission. This paper attempts to review the more important aspects involved in such filter measurements and includes a summary of previous investigations concerned with the establishment of the constants for the standard type filters recommended by the World Meteorol. Organization. Tables are given to facilitate correcting solar radiation measurements made with filter specimens exhibiting different characteristics within the same glass type to standard conditions. Tabular values indicating the general effect on measurements introduced by variation of 10 mμ in the lower cut-off position (a shift which has frequently occurred is samples of the same glass type from different melts); the information relates to solar radiation at specified air mass and turbidity. (Authors' abstr. cond.)

3884. Values of Parameters Appearing in Sutton's Diffusion Models. D. A. HAUGEN, M. L. BARAD, and P. ANTANAITIS. *J. Meteorol.* **18,** 368–72 (June 1961).

Statistical summaries are presented of computed values of parameters appearing in a modification of Sutton's diffusion equations. Experimental data used for the computations are those obtained during Project Prairie Grass at O'Neill, Nebr. and at Round Hill, Mass. Detailed descriptions of the experimental techniques used as well as tabulations of the basic data are given in the references. However, a tracer gas, SO_2, was released continuously from a point source at heights of 46 cm. in 64 and 150 cm. in 6 of the Prairie Grass and at heights of 150 cm. in the Round Hill experiments. The parameter, C_γ, has a mean value of about 0.4 for the Prairie Grass, and about 0.9 for the Round Hill experiments. No relationship between C_γ and stability was found for the Prairie Grass experiments, but a correlation coefficient of 0.22 between $C\gamma$ and stability ratio was found for the Round Hill experiments.

3885. Stratospheric Aerosol Studies. C. E. JUNGE and J. E. MANSON. *J. Geophys. Research* **66,** 2163–82 (July 1961).

The stratospheric aerosol layer previously identified by balloon measurements has been studied extensively by means of recovered rod impactor samples obtained during aircraft flights at the 20-km. level from 63°S. to 72°N. during Mar.–Nov. 1960. From a variety of physical and chemical measurements, which are presented in detail, it is concluded that this layer is stable, constant in time and space, and composed mainly of sulfate particles. The various questions raised by this result, particularly with respect to collection of micrometeorites, are presented and discussed. The discussion on methods for cosmic dust collection has been included because many workers in this field are not fully acquainted with the special conditions which apply to particle collection in the stratosphere. Collection by direct flow impactors of proper design, mounted on aircraft, is the most promising method for stratospheric aerosol studies involving individual particle identification.

3886. Meteorological Aspects of Large Scale Air Pollution. L. MACHTA. *Public Health Repts.* **75,** 307–12 (Apr. 1960).

Although our immediate concern is with the damage to health and to agriculture, the consequences of air pollution reach beyond these effects. There is strong evidence that increased atmospheric contamination reduces visibility and modifies electrical conductivity, precipitation, and the radiation balance. What subtle and far-reaching effects will result from these and other phenomena are now unknown. Most air pollutants are not destroyed by disposing of them downwind of a city. Under some circumstances pollutants from several cities may combine and affect areas far removed from the sources of pollution. Three weather factors are thought to favor air pollution episodes on a large scale: (1) small dilution due to light winds and a low altitude thermal inversion which inhibits upward mixing; (2) the absence of rain scavenging; and (3) the persistence of this weather for several days, permitting the accumulation of pollutants. Some of the meteorological aspects of large-scale air pollution are discussed. Prevention of dispersion of wastes into the atmosphere is, of course, the best way to avoid air pollution episodes. Failing this, the meteorologist continues his contribution, with the assistance of health officials, by monitoring the atmosphere's cleanliness. Secondly, he can increase his efforts to devise adequate methods for predicting the dilution, transport, and removal properties of the atmosphere in case meteorological control becomes necessary. This would mean permitting the release of pollutants only at times when weather conditions favorable to dilution have been forecast. (LC)

3887. The Absorption of Solar Radiation by Water Vapor and Carbon Dioxide in a Cloudless Atmosphere. W. T. ROACH. *Quart. J. Meteorol. Soc.* (London) **87,** 364–73 (July 1961).

A method of computation of the direct absorption of solar radiation by the near infrared bands of water vapor and carbon dioxide in a cloudless, non-scattering atmosphere using recent laboratory data is described. Three applications of this computation are discussed: (1) Heating rates in an atmosphere whose water vapor distribution is given by radiosonde or aircraft observations. (2) Instantaneous heating rates as a function of solar zenith angle, altitude, and precipitable water vapor. (3) A climatological study of heating rates in a cloudless atmosphere integrated over a 24 hr. period as a function of latitude, season, altitude, and precipitable water vapor. The relative contributions to heating by water vapor and carbon dioxide are assessed between 10 and 1000 mb. The mixing ratio of carbon dioxide was assumed constant throughout the atmosphere, while idealized vertical distributions of water vapor mixing ratio were used in (2) and (3). (Author's summary cond.)

3888. The Relationship between Peak and Mean Concentrations. I. A. SINGER. *J. Air Poll. Control Assoc.* **11,** 336–41 (July 1961).

A method of predicting average concentrations has been presented. It has been shown that the simplified normal bivariate distribution describing the average concentration pattern is composed of various short-term periodic distributions which may differ from it significantly. A descriptive, empirical method has been described which indicates an exponential relationship exists between these shorter time or peak concentrations and average conditions. The slope of the exponent appears to be proportional to the stability or gustiness. Downwind, the peaks are normally within an order of magnitude greater than average concentrations, whereas crosswind, the peaks may be several orders of magnitude larger. (Author's summary)

ANALYSIS, DETECTION, MEASUREMENT, MEASUREMENT EQUIPMENT, MEASUREMENT METHOD, RESEARCH, SAMPLING, TECHNIQUES TESTING

3889. Alpha Counter for the Direct Determination of Plutonium in Solution. J. T. BYRNE and G. A. ROST. *Anal. Chem.* **33,** 758–61 (May 1961).

The necessity of determining plutonium rapidly in solution has prompted the design and construction of solution α counters in which the sample solutions do not require chemical or physical treatment. The theory, design, advantages, and limitations of the α counters are discussed. The laboratory solution counter can rapidly determine 5 x 10^{-4} to 5 g. of plutonium/l. of solution with a reproducibility of better than ±5%. The effects of density of the solution and other factors that affect accuracy have been evaluated.

3890. Recent Observations Regarding the Epidemiology and Pathogenesis of Sarcoidosis. P. W. CLOUGH. *Ann. Internal Med.* **51,** 174–8 (July 1959).

Intensive work has been devoted to the study of sarcoidosis but the information amassed still gives no positive information as to its etiology and pathogenesis. Various differences in clinical, histological, and therapeutic aspects between sarcoidosis and tuberculosis are reviewed. In view of the failure to demonstrate any specific causative agents in sarcoidosis the theory has been advanced that the disease depends upon an abnormal reactivity on the part of the host. The well-known insensitivity to tuberculin could be one manifestation of this, and the development of epithelioid cellular nodules in response to certain irritants (such as silica particles) or pathogenic agents might be another. A new approach to the problem has been reported following an extensive epidemiological study of armed forces personnel during World War II. A marked concentration was found of patients whose birthplace had been in rural areas of the southeastern states, with a high proportion of Negroes. Another factor was that the highest incidence occurred in regions covered by a Red Yellow Podzolic soil. A latter study originating from a Veterans' Hospital indicated the origin of cases to be outside the range of this type of soil and found instead a correlation with nonarid areas of the U. S. and a high correlation with the distribution of forests (pine pollen). (LC)

3891. [Data for Determining the Maximum Permissible Concentration of Acetone in the Atmosphere.] Materialy k obosnovani͡iu predel'no dopustimoĭ kont͡sentrat͡siĭ atsetona v atmosfernom vozdukhe. IU. G. FELDMAN. *Gigiena i Sanit.* (Moscow) **25,** 3–10 (May 1960).

The work was aimed at obtaining experimental data which could serve as hygienic background for determining the maximum permissible concentration of acetone in the atmosphere. The effect of small concentrations of acetone on man was studied under laboratory conditions. For acetone the threshold value of olfactory sensation for most susceptible individuals was 1.1 mg./m.^{3}, that of reflex action on the light sensitivity of the eye 0.55 mg./m.^{3}, and of reflex action on cerebral electric activity 0.44 mg./m.^{3}. After 45 days of continuous poisoning with acetone at a concentration of 0.53 mg./m.^{3} no changes could be detected in white rats under experimental conditions either in the motor chronaxy and in the blood-picture or the weight and histological picture of their internal organs. At a distance of 100 m. from an acetone silk plant the maximum one-time concentration of acetone in the atmosphere was 6.48 mg./m.^{3}; at a distance of 300 m. it was 1.08 mg./m.^{3}; and at 750 m., 0.2 mg./m.^{3}. Neither the maximum permissible one-time nor the average daily concentration of acetone in the atmosphere should exceed 0.35 mg./m.^{3}. (Author's English summary—LC)

3892. [Thermophoresis in an Aerosol Flow.] O termoforese v potoke aerozolia. N. A. FUKS and S. S. IANKOVSKII. JPRS L-627-N. Feb. 12, 1959, 5 pp. Available for **$0.50, as 59-13117,** from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Trans. from: **Akad. nauk S.S.S.R. Doklady* (Moscow) **119,** (6) 1177–9 (1958).

The force Facting on aerosol particles at the temperature gradient G can be determined for two limiting cases. If the particle size d is extremely small in relation to the mean free paths of the gas molecules λ, $F = -(\pi d^2 p \lambda G/8 T)$, where p is the pressure and T is the absolute temperature. If $d > > \lambda$, the force $F = -(9 \pi \beta \eta^2 d G/2 T)$, where η is the viscosity, λ the density of the gas and $\beta = X_a/2X_aX_1$, X_a and X_1 being the thermal conductivities of the gas and the particles. In both limiting cases the speed of thermophoresis depends upon d and should be much larger for $d < < \lambda$ than for $d > > \lambda$. If $d \approx \lambda$, the theory of the phenomenon becomes very complex. The inertia hinders precipitation, but deviates the particles from their trajectories; this deviation was 1 to 2 μ for NaCl particles of 4 μ. At gradients of several 100 μ, this was not substantial. Particles close to the wall of the observation vessel were affected by the repulsive force $F = (9/64) \pi \gamma d^2v^2$ equivalent to 8×10^{-13} dynes. In ordinary thermoprecipitation G has the value of 5000°C/cm., and the thermophoretic forces is 10^{-8} dynes. These findings are neither in accordance with the theory nor with recent experiments by Kogan and Repina [this journal, *111,* 851 (1956)]. (LC)

3893. The Role of the Public Health Laboratory in Air Pollution Programs. H. L. HELWIG and J. A. MAGA. *Amer. J. Public Health* **50,** 933–6 (July 1960).

The role of the public health laboratory in an air pollution program is dependent upon the program responsibility of the department of public health. In the dynamic field of air pollution, these responsibilities are continually changing to meet new needs and to apply the new research findings. In nearly four years of activity, the Air Industrial Hygiene Laboratory of the California State Department of Public Health has developed its contribution in the areas of laboratory support of programs of air pollution measurement, development of laboratory methods for analysis and epidemiological applications, research on the chemical and physical nature of air pollutants, and the relating of results of research on air pollution to the program of the department. (Authors' summary—LC)

3894. Evaluation of the Origins of Strontium-90 Contained in Wheat Plant. R. ICHIKAWA, M. ABE, and M. ETO. *Science* **133,** 2017–18 (June 23, 1961).

For evaluation of the Sr^{90} hazard level in the future, the argument concerning radioactive contamination of wheat and other cereals by fallout has been narrowed down to the problem of how much Sr^{90} in grain depends on the cumulative Sr^{90} deposition in soil and how much depends on the current Sr^{90} fallout rate. In 1959, 20% of the Sr^{90} in wheat flour was due to root absorption, 30% to floral absorption from soil particles attached to the ear, and 50% to current fallout. In 1960, 35% was due to root absorption, 50% to floral absorption from soil, and 15% to current fallout. The present level of Sr^{90} in wheat flour is approx. 80–90%, originating from soil contamination.

3895. Exhaust Gas Oxidation on Vanadia-Alumina Catalysts. W. B. INNIS and R. DUFFY. *J. Air Poll. Control Assoc.* **11,** 369–73 (Aug. 1961).

An approach is outlined for studying the kinetics of exhaust gas oxidation using data on vanadia-alumina catalyst composition to illustrate the method. First order kinetics fit available data and the activation energy for the pure olefin oxidation by excess air is about 17 kcal. and that for CO is 21 kcal./mol. Oxidation rate constants in exhaust gas appear about equal to the product of the pure gas constant times the fraction of vanadium in the pentavalent state except for pentane and hexane which are much lower. The rate constant for pure compound oxidation increases markedly with degree of unsaturation and molecular weight. Activity for oxidation of ethene at 405°C. and propene at 325°C. directly correlated with V_2O_5 content up to 24%. On thermal deactivation, oxidation activity normally increases or stays constant down to about 70 m.^{2}/g. and thereafter is proportional to surface area. (Authors' summary)

3896. [Study of Fine Dusts with the Lambda-Variation Method in Phase Contrast.] Untersuchung von Feinstäuben nach der λ-Variationsmethode im Phasenkontrast. J. JUDA and K. MEDENBACH. *Z. wissenshaft. Mikroskopie u. mikroskopische Technik* (Stuttgart) **64,** 218–26 (Sept. 1959).

The λ-variation method in phase contrast permits a clear separation of ultra-small dust particles at a sensitivity ten times greater than the dye immersion method. Once the dispersion curves of substances under investigation in an unknown sample and the suitable immersion fluids have been determined, the wavelengths can be deduced at which the phase contrast becomes zero; in practice this leads to a clear recognition and determination of the individual component (with the exception of bi-axially anisotropic components in any position). The method can be used wherever various substances or mixtures of substances can be individually immersed in a highly dispersing fluid whose dispersion curve intersects that of the substances to be determined within the visible wave range. It can above all be applied to light-microscopical mineralogical dust examination, where it offers certain advantages over the other method. On the other hand, the dispersion curve of this fluid can be determined more easily by this method than by any other with the aid of suitable glass dust of known composition (test dust), within the range of a fluid dispersion curve. (Authors' summary—LC)

3897. The Identification of Aliphatic Amines in Air as Their Benzamides by Paper Chromatography. J. P. LODGE, JR. and E. D. BARBER. *Anal. Chim. Acta* (Netherlands) **24,** 235–40 (Mar. 1961).

A method is described for the separation of amines as their benzamides by paper chromatography. Data are given on separations in 2 systems. Homologous benzamides from C_1 to C_{10} are best separated on S & S 2040a paper while C_{10} and C_{12} are separated on 2045a paper. When radiocarbon labelled benzamides were chromatographed and placed on x-ray film for 8 to 10 days with subsequent development of the radioautograph, the lower limit of identification was found to be 2.5 μg. of each benzamide. The results of analysis for amines in 2 samples of air particulate matter, and 1 of atmospheric vapors are presented. (Authors' summary)

3898. Vehicular Exhausts: Identification of Further Carcinogens of the Polycyclic Aromatic Hydrocarbon Class. M. J. LYONS. *Brit. J. Cancer* (London) **13,** 126–31 (Mar. 1959).

Fractions isolated from petrol engine and diesel engine exhaust samples were assayed for the presence of polycyclic aromatic hydrocarbons. The fractions examined had all succeeded 3,4-

benzpyrene in initial chromatographic runs. The methods employed were repetitive absorption chromatography on alumina and silica gel, followed by ultra-violet adsorption and spectrographic analysis of the eluates. By these methods the following compounds were identified in the petrol engine exhaust sample: 3,4-benzfluoranthene; tetracene (naphthacene); pentaphene; 1,2,3,4-dibenzpyrene; 11,12-benzfluoranthene; 1,2,9,10-dibenztetracene; 1,2,4,5-dibenzpyrene; and 1,12,2,3-dibenzperylene. In the diesel engine exhaust sample, the following compounds were identified: 3,4-benzfluoranthene; pentaphene; 1,2,3,4-dibenzpyrene; 1,12-benzfluoranthene; and 1,2,9,10-dibenztetracene. Of the above compounds, the 3,4-benzfluoranthene; 1,2,3,4-dibenzpyrene; and 1,2,4,5-dibenzpyrene are carcinogenic, while the 1,12,2,3-dibenzperylene, it is believed, has not yet been tested. This is the first time, it is thought, that the latter two compounds have been identified in any pyrogenic material. (Author's summary—LC)

3899. Continuous Polarographic Analysis in Industrial Process Control. W. J. PARKER. *Research* (London) **14,** 224–31 (June 1961).

In many industries, batch polarographic analysis is common practice and the availability of suitable equipment for continuous analysis will result in the widespread introduction of continuous monitoring with improvements in process efficiencies. Continuous polarographic analysis is used for detection, measurement, prevention of chemical corrosion, and mechanical erosion in process plants. Also for detecting and preventing atmospheric pollution in industrial buildings, such as the emission of cyanide vapors in electroplating shops, toxic fumes in process plants, mines, tunnels, submerged vessels, and other enclosed working spaces. Continuous polarographic analysis is gradually being introduced into medicine in Britain. It is used for diagnosing heart diseases by monitoring variations in oxygen content of blood streams, *in vivo.* 35 references.

3900. Determination of Lead in Gasoline by Atomic Absorption Spectroscopy. J. W. ROBINSON. *Anal. Chim. Acta* (Netherlands) **24,** 451–5 (May 1961).

A procedure has been developed for the determination of lead in gasoline by atomic absorption spectroscopy. This procedure is rapid, does not require expensive equipment, is remarkably free from interference by other trace elements present, and allows variation in the sulfur and nitrogen content of the gasoline. It compares favorably with other existing procedures for this determination such as x-ray fluorescence, wet chemical methods, and flame photometry. Time for complete analysis, including calculations is approx. 10 min.

3901. [The Method of Experimental Determination of the Permissible Limits of Concentration of Atmospheric Pollution.] K methodike eksperimental'nogo obosnovaniia predel'no-popustimykh kontsentratsii atmosfernykh zagryaznenii. V. A. RIAZANOV, K. A. BUSHTUEVA, and IU. V. NOVIKOV. * Abstr. Soviet Med. Pt. B—Clinical Med. **3,** (1) 318–9 (1959). Trans. from: *Predel'nodopustimye kontsentrat. atmosfernykh zagriaznenii* (Moskva) **3,** 117–51 (1957).

Methods of investigation, which have been employed during recent years in a number of studies on the determination of permissible limits of concentration of atmospheric pollution, are described. The following were carried out on the instructions of the Commission of the Chief Governmental Sanitary Inspection Authority of the USSR: (1) Method of ascertaining the constancy of concentration in the air of the substance investigated. According to which particular substance is concerned, it is advisable to use one of 4 variations of the method. (2) Methods of determining the smell threshold and the irritation threshold for mucous membranes of the substance investigated. (3) Method of pneumographic determination of the threshold of activity of the substance investigated. (4) Method of examining the optic chronaxy for the determination of the threshold of reflex action of the substance investigated. (5) Determination of the threshold of reflex action of the substance investigated by means of adaptometry. (6) Method of the study of conditioned reflexes in white mice. (LC)

3902 Spot Test Detection and Colorimetric Determination of Aromatic Amines and Imino Heteroaromatic Compounds with 3-Methyl-2-Benzothiazolone Hydrazone. E. SAWICKI, T. W. STANLEY, T. R. HAUSER, W. ELBERT, and J. L. NOE. *Anal. Chem.* **33,** 722–5 (May 1961).

A new analytical method is introduced for the detection and determination of organic nitrogen compounds. The reagent, 3-methyl-2-benzothiazole hydrazone is used for qualitative determinations of organic compounds. Although an attempt has been made to report the best general procedure for the type of compounds investigated, it is necessary to emphasize that modification of the general procedure might be necessary to obtain optimum results for the analysis of any one particular compound. Many carcinogenic amines were determined by the colorimetric method. The new analytical procedure gives positive results with a large number of aromatic primary, secondary, and tertiary amines.

3903. Use of Indexes of Air Pollution Potential in Mortality Studies. R. SCHIFFMAN and E. LANDAU. *J. Air Poll. Control Assoc.* **11,** 384–6 (Aug. 1961).

At present there are no completely adequate data for categorizing level of air pollution throughout the U. S. A large number of indexes have been prepared by the Air Poll. Med. program for use as indirect measures to study the possible relationship between these imputed measures of air pollution and mortality. The construction of these indexes is based on potential sources of air pollution such as measures of home heating, specific and nonspecific industry, and service station sales. A particular method has been demonstrated in which a number of indexes can be used as tools for medical research. The relationships of certain air pollution indexes with mortality from selected diseases have been examined and show that positive relationships exist. There are sufficient statistical relationships in this work to indicate the need for further research and study. (Authors' summary cond.)

3904. Process Monitoring by Gas Chromatography. R. P. W. SCOTT. *Research* (London) **14,** 113–17 (Mar. 1961).

Gas chromatography has been applied to the examination of volatile substances present in coal gas, produced in a coke oven. Gas chromatography is used for following plant processes and in the analysis of hydrocarbon gases, inorganic gases, petroleum fractions, and coal tar products. Some advantages of the techniques for monitoring plant streams are considered. Recent developments of high sensitivity detectors are discussed together with high efficiency columns, and in high speed analysis. Examples of process monitoring from both industry and research laboratories are given.

3905. Water and Atmosphere. H. E. STOKINGER. *Federation Proc.* **19,** (3) (Pt. II, Suppl. no. 4), 26–30 (Sept. 1960).

This Supplement is devoted to the Proceedings of a Symposium on Problems in Toxicology, held in Chicago, Illinois, April 13, 1960.

One of the biggest problems in air pollution is the analysis and identification of the pollutants. Although much work has been done, the substance(s) responsible for eye irritation, found in many areas during periods of smog, have yet to be identified. The composition of the exhaust products of combustion engines are fairly well known but too little is known of the products of photochemical, chemical, or catalytic interactions. New methods are needed for capturing and identifying fleeting complex radicals, molecules with short half lives in the parts-per-billion range. In Table 3 in the text are outlined some of the recognized air pollutants with their potential health effects. Under oxidants are listed O_3, NO, NO_2, NOBr (respiratory tract irritants); organic peroxides, peroxyaldehydes (radiomimetic properties?); organic free radicals, air ions (immunogenic activity?-carcinogenic activity?). Under hydrocarbons are the polycyclic hydrocarbons (carcinogenic activity); gasoline—olefins, branched chain saturated (react with oxidants); oil mists—naphthenes (counteract effect of oxidants). The metal oxides are noted as Fe_2O_3, V_2O_5, MnO_2, etc. (oxidizing catalysts producing more potent oxidants). The reducing gases are mentioned as SO_2, SO_3 mist (respiratory tract irritants); CO (reduces O_2 transport); H_2S, H_2S_x, mercaptans, organic disulfides (counteract effect of oxidants). The metals and metal compounds are noted, such as Pb, As, Cr, etc. (add to body metal burden). The chemical synthetics, solvents, etc., are mentioned but not named. Although much needs to be known about the long-term effects of combinations of air pollutants, it is necessary also to know a great deal more about the effects of single air pollutants. (LC)

3906. [Criteria for the Assessment of Measurement Processes for Gaseous Immissions.] Kriterien zur Beurteilung von Messverfahren für Gasförmige Immissionen. H. STRATMANN. *Staub* (Düsseldorf) **21,** 118–21 (Feb. 1961).

In the largely indeterminate, multicomponent system of a polluted atmosphere it is difficult to find any relationship between the measured value and the molecular disperse concentration of a gaseous substance present, in the sense of the MIK value definition. The various possible disturbing influences which render difficult the exact physical and chemical definition of the substance to be determined are indicated. They do not fundamentally interfere with the application of air analysis but should be taken into account to avoid misunderstanding and erroneous verdicts in the assessment of the measured values obtained by a certain measuring method. (English summary)

3907. [The Use of Air Analysis for Determining the Effects of Sulfur Dioxide on Vegetation.] Die Anwendung der Luftanalyse zur Beurteilung von Schwefeldioxyd-Einwirkungen auf die Vegetation. H. STRATMANN. *Staub* (Düsseldorf) **21,** 61–4 (Feb. 1961).

Maximum immission concentrations, MIK-values, are laid down to limit permissible immissions. They are derived from so-called tolerance limits which are obtained from the relationship between the immission and its harmful effect. In the effects of sulfur dioxide on vegetation it has been shown how the tolerance limits are obtained from the threshold of irritation function. They are not identical to the MIK-values which can only be derived from them by means of an additional definition. Above all the permanently changing conditions of immission are decisive for this additional definition. This must be taken into account if supervision of the MIK-values is to be made possible by the aid of air analysis. (English summary)

3908. [The Separation of C_2–C_5 Hydrocarbons by the Method of Gas-Liquid Partition Chromatography.] O razdelenii uglevodorodov C_2–C_5 metodom gazozhidkostnoi raspredelitel'noi khromatografii. N. M. TURKEL'TAUB, B. I. ANVAER, A. I. KOLI͡UBI͡AKINA, and M. S. SELENKINA. *Ind. Lab.* **25,** 159–63 (Mar. 1960). Transl. of: *Zavodskai͡a Lab.* (Moscow) **25,** 149–54 (Feb. 1959).

The separation of components by partition chromatography is based on differences in their rates of passage through a bed of adsorbent impregnated with solvent. It is possible to vary the properties of the adsorbent within wide limits, by changing the ratio of solvent to adsorbent carrier, and by using a mixture of two or more solvents. When separating hydrocarbons of a single homologous series, it is normal to use a nonpolar substance such as vaseline oil as a solvent. But when separating components close to their boiling points, and differing greatly in structure, it is necessary to use a polar solvent as stationary phase. It is stated that a complete separation of a mixture of saturated and unsaturated hydrocarbons from C_2 to C_5 with determination of all isomers, has not been described in the literature. In order to achieve this, the current study investigated the function of the nature of the stationary phase in the separation of hydrocarbons C_2-C_5. It was found that for each solvent used as a stationary phase in gas-liquid chromatography, and for each adsorbent carrier, there was an optimum ratio of solvent-to-carrier to give the best separation of the components of a mixture. It was not possible to separate completely all the isomers of the C_4 and C_5 hydrocarbons even with the optimum ratio of adsorbent-to-solvent but the problem was solved by using mixed solvents. Addition of 1% vaseline oil to dimethylformamide (brick as carrier), or of 6.5% of triisobutylene (diatomite as carrier), made it possible to separate completely the isomers of the hydrocarbons C_4 and C_5. (LC)

3909. [The Analysis of Sulfur Dioxide Effects on Plants in Laboratory Experiments.] Die Analyse von Schwefelddioxydwirkungen auf Pflanzen im Laboratoriumsversuch. H. VAN HAUT. *Staub* (Düsseldorf) **21,** 52–6 (Feb. 1961).

The evaluation of tolerance limits for sulfur dioxide requires knowledge of the quantitative relationships between the immission and the effect. On the basis of gas exposure experiments in climatic chambers it has been possible to follow the relationship between plant reaction and the individual influencing factors. It has been possible to obtain particular information about the relationship between the harmful effect and the concentration of the sulfur dioxide and the length of time for which it acts, and also about the significance of the stages of development of the reaction of plants to SO_2 influences. Important indications have been obtained from this for the evaluation of tolerance limits in the open air experiments. (English summary)

3910. Resolutions of the International Symposium on Maximum Allowable Concentrations of Toxic Substances in Industry, Prague, 14–17 April 1959. *Med. lavoro* (Milan) **51,** 389–92 (May 1960).

It is stated that, since the international adoption of a single list of hygienically acceptable values for concentration of toxic application, the symposium recommended the preparation and continued revision of such lists, to be called "Maximum Allowable Concentrations (M.A.C.'s)," by the Subcommittee of the Permanent Committee of the International Association on Occupational Health. In the 4th section of the resolutions entitled "Importance of Suitable Methods of Physical or Chemical Analysis" it is noted that if any toxic substance is used in a factory or workshop which may cause atmospheric contamination, that fact should be known by a responsible authority. He also should be aware of the nature and amount of any toxic impurity in the material used. It is further stated that regular air analyses are probably the best means of providing the information required to control atmospheric contamination. (LC)

3911. Simplified Techniques in Air Pollution Measurement. Leaflet No. 118. **Eng. Progr. Univ. of Florida* **14,** 1–8 (Mar. 1960).

Some simplified techniques are described which have been used in air pollution research projects at the University of Florida for such purposes as defining the geographical limits of a polluted area, confirming selected locations for volumetric samplers in a network, and estimating vertical concentration in conjunction with a volumetric sampler at ground level. They have been found quite satisfactory for these purposes and should be for many applications where dosimeter-type measurements are needed. Research should be directed toward producing more such simplified techniques for a wide variety of contaminants, for use in pollution measurements, keeping in mind always the two factors of simplicity and low cost. Such a technique for sulfur dioxide is the earliest dosimeter method. It is the lead peroxide candle method, a cumulative procedure involving the rate of sulfate formation by exposing lead peroxide paste to sulfur dioxide. One method for estimating the proximity to a source of suspected fluoride emission involves the use of Spanish moss which is a cumulative absorbent for volatile fluorides. Another method involves a similar technique using limed filter papers in place of the moss. A method for hydrogen sulfide estimation, which originated with sewage plant workers, involves the use of lead-acetate-impregnated papers or tiles with the latter being preferred. Again no quantitative estimate can be made but the relative exposure of various localities to hydrogen sulfide can be determined. In using rubber strips for determination of ozone in the air, several methods of preparation of the strips of rubber and of measurement of the crack depths are discussed. (LC)

AREA MEASUREMENT, SURVEYS

3912. Air Pollution. P. DRINKER. *New Engl. J. Med.* **264,** 754–9 (Apr. 13, 1961).

Present day Los Angeles smogs differ from the London type of fog in that they occur at noontime in warm weather, not cold; the air is oxidizing, not reducing; the pollutants and the meteorology are different; and the eye-smarting visitation occur as often as 30 or 40 times yearly rather than infrequently. The Los Angeles smogs began to scar the green-leaved vegetables, like spinach and lettuce, when gasoline consumption reached the levels current about 1944. In general, plants cannot be used as indicators of pollution levels bothersome to man since plants are, for instance, unaffected by CO and hydrocyanic acid in concentration dangerous to man but are far more sensitive to SO_2 than is man. An instance is cited of the occurrence in both England and the U. S. of melanism in the peppered moth (*Biston betularia*). Since the synergistic effects of combinations of smog elements are becoming increasingly known, it may be that fractional control of one component known to be harmful may be more practical and much easier than control of all impurities. California, and especially Los Angeles, considers the promise of successful means of controlling automobile exhausts good enough to have passed a law which will go into effect as soon as at least two devices for controlling exhaust fumes are approved by the State. It should be remembered that California's antipollution laws are tailored to meet the requirements of its unusual weather and meteorology and may not remedy conditions in other areas. Cars in the very near future will probably be equipped with a recirculation pipe that leads the unburned vapors of blowby and crankcase vent gases into the air intake of the vehicle where they will be burned. Despite the possible use of a fuel cell, to convert directly into low voltage the electrical energy from the chemical energy of a conventional fuel, and thus reduce the amount of pollution, there is no indication at all that the traffic problem in any of the large urban centers would be reduced. Most odors are from combustible material which can be burned, and are not considered to be health problems. The toxic air pollutant concentrations for Los Angeles County, are given (in ppm. by volume) for the 1st, 2nd, and 3rd alerts, for: carbon monoxide, 100, 200, and 300; nitrogen oxides and sulfur oxides are similar as 3.0, 5.0, and 10.1; and ozone, 0.5, 1.0, and 1.5. (LC)

3913. A review of Air Pollution in New York State. New York State Air Pollution Control Board. H. E. HILLEBOE, Chairman. July 1958. 76 pp.

The New York State Air Pollution Control Act was passed in 1957. A nine-member Air Pollution Control Board was created, composed of five state department commissioners and four other members representing the medical and engineering professions, industry, and local government. Broad powers and responsibilities were given to the Board but rule-making and enforcement authority did not become effective until July 1, 1959. Three statewide surveys had previously been made to assess New York's air pollution problem. The results correlated reasonably well to produce a comprehensive picture of air pollution in New York State. Of the state's 40 communities with populations of more than 25,000, only one had negligible air pollution. Approximately three-fourths of communities of 5,000 to 25,000 population and about one-third of those with less than 5,000 people, had major or minor air pollution. The study emphasized the fallacy of trying to appraise the situation only by spotting large metropolitan areas and industrial centers on a map since problems were found in some very low population communities. Open dumps were the most frequently reported sources of air pollutants in both categories. Except for New York City, where there is an acknowledged problem and an active control program, practically no air-sampling equipment was found in the state. Nine study areas have been proposed for the activities of the Board, the most pressing problems being in New York City and the Niagara Frontier areas. The proposal is subject to drastic revision and modification later depending on the outcomes of emission-inventory and air-sampling projects to be conducted by the Board. (LC)

3914. Social and Environmental Factors in Chronic Bronchitis in Newcastle upon Tyne. A. G. OGILVIE. *Postgrad. Med. J.* (London) **36,** 261–9 (Apr. 1960).

This study of the important social and environmental factors in chronic bronchitis has been based on the findings of a survey of other authors who carried it out in Newcastle in 1955–56. It has also been amplified by references to the literature. Mortality and sickness due to bronchitis both bear a direct relationship to the degree of urbanization, being lowest in the country. Pollution of the atmosphere has been considered to be a major etiological and aggravating factor, but it has been emphasized that its effects are enhanced by the older "closed" type of housing arrangement. Urban life, though it affects the rates for death and for incapacity, does not alter the male preponderance. If smokers and non-smokers are separately analyzed, the difference is greatly reduced. Constitutional influences are significant, although no accurate estimation of their importance is yet possible. Infection, though known to be an essential feature of established bronchitis, is difficult to demonstrate epidemiologically. The fact that rural prevalence of bronchitis almost equals urban prevalence, despite the higher death and sickness rates, indicates that the town-dweller's bronchitis is more severe; and underlines the need for clinical criteria of aggravation, so that study of the causes of aggravation can go forward. (Author's summary, modified—LC)

3915. Sheffield's Clean Air Campaign. F. ST. D. ROWNTREE. **Health Educ. J.* (London) **18,** 25–32 (Mar. 1960).

The reputation of the city of Sheffield as being one of the blackest and smokiest in the country is said to be, in general, unjustified since most of the pollution is centered around the industrial valleys and not spread evenly over the remainder of the city. Following the enactment of the Clean Air Act of 1956, plans were begun to survey the city for the creation of smokeless zones with the first of these to come into being on Dec. 1, 1959. Since it was felt that a publicity campaign should precede this, the recently created Health Education Service undertook a clean air publicity campaign. The object of the campaign was to provide information on the causes and effects of atmospheric pollution and the ways being used to combat them, and to show the general public how they could cooperate in fighting pollution whether they lived in smokeless zones or not. A local press conference was called a month before the inauguration of the main campaign, followed by the use of various publicity media such as posters, leaflets, and films. In mid-November the climax was reached with the official inauguration of the major campaign and the opening of the clean air exhibition. This opening was considered to be a civic occasion with a luncheon and activities at the Town Hall. Evaluation of the campaign was carried out by means of questionnaires given to the public in various localities throughout the city and at the exhibition. Initially the general attitude to conversion of household appliances had been one of apathy or mild hostility but as the campaign proceeded there was a distinct change in favor of conversion of household appliances. An analysis of questions asked at the exhibition indicated that more than 75% of the people wanted to know when their areas could become smokeless zones. A very sharp rise in the sale of approved appliances and requests for information concerning conversion, was reported. (LC)

3916. The London Fog of December 1957. J. A. SCOTT. *Med. Officer* (London) **99,** 367–8 (June 20, 1959).

Results of the investigations on the relation between atmospheric pollution and "excess" deaths in the London area during January 1956 and December 1957, respectively, are presented. A level of pollution critical for health was reached when the daily concentrations of smoke and sulfur dioxide in the atmosphere were of the order of 200 mg. of black suspended matter per 100 $m.^3$ of air and 40 parts of SO_2 per 100 million parts of air. During a fog in January 1956, which attained this level, 480 "excess" deaths were registered. During the smog in December 1957, the smoke attained 84% and the sulfur dioxide 120% of the values in 1956; some 300 "excess" deaths were estimated from the mortality curve, excluding 90 deaths in a railway disaster caused by the fog. This time the smog affected people both under and over 70 years of age, unlike that in 1956 when chiefly the older people were affected. In 1957, about $^1/_3$ of the "excess" deaths belonged to the age group of 50–70 years. Before definite conclusions can be drawn, more observations must be made. (Author's summary—LC)

3917. Air Pollution and Health. W. S. SPICER. **Maryland State Med. J.* **9,** 688–93 (Oct. 1960).

The list of possible air contaminants in each of the areas of the three major air pollution episodes—London, 1952; the Meuse Valley, 1930; Donora, 1948—contains materials not found or not likely to be found, quantitatively or qualitatively, in the other two. Some of the facts which apply to all three episodes, are outlined. There have been at least two outbreaks of asthmatic attacks among adults without previous history or present evidence of allergy. Both of these, one among Army personnel in Japan in 1946 and the other in New Orleans in 1958, resembled acute attacks of bronchitis but occurred during periods of low wind and high air pollution, particularly from sulfur dioxide. In experiments with human volunteers using sulfur dioxide, two experimenters became sensitive to SO_2 and developed a persistent bronchitis with wheezing when exposed to this agent. The knowledge of the effect of exposure to low concentrations of air pollution or chronic effects on health stem predominantly from epidemiological surveys and concerns especially bronchitis in Great Britain and Los Angeles, and bronchogenic carcinoma. At the present time, a study of the day to day variation in the clinical and physiological status of a large group of patients with chronic bronchitis is underway in Baltimore. (LC)

3918. [Problems of Air Pollution in Czechoslovakia.] Problém znečištováni vozduší v Československu. K. SPURNÝ and E. LOCHMANOVA. **Energetika* (Prague) **9,** (10) 510–11 (1959).

Studies were made of the degree of air pollution over 21 cities of Czechoslovakia during the period of 1954–59. Measurements were made of the average dustfall, as well as the content of SO_2, Cl_2, and of NO plus NO_2 in the atmosphere. Some of the data obtained are given in the following table:

City	Dustfall (tons/ $km.^2$/year)	SO_2 ($mg./m.^3$)	Aerosol (mg./m.)
1. Tábor	75		
2. Vrchlabí	98		
3. Jihlava	128		
4. Nová Paka	181		
5. Strakonice	190		
6. Brno	195		
7. Příbram	200	0.25	
8. České Budéjovice	216	0.009	0.33
9. Karlovy Vary	302		
10. Praha [Prague]	331	0.065	0.66
11. Kladno	400		
12. Plzeň	418		
13. Beroun	450		
14. Sokolov	702		
15. Poříčí	750	0.16	
16. Ostrava	1018		
17. Králův Dvůr	1300		
18. Stará Role	1487		
19. Ústí nad Labem	1550		
20. Ervěnice	1969		
21. Komořany	3600		

An increase in the amount of air pollution was found to be associated with the increase in industrialization of the area, especially that associated with the coal-producing industries. The effects of gaseous deposits on the forests are mentioned. The average concentrations over a 24-hour period of various substances in the atmosphere and the maximal peaks of concentration are given as follows:

Substance	Average concentrations per 24 hours (mg./m^3)	Maximal peaks of concentration (mg./m.^{3})
H_2S	0.005	0.015
SO_2	0.15	0.50
H_2SO_4	0.10	0.30
CO	2.0	6.0
NO plus NO_2	0.13	0.40
Cl_2	0.03	0.1
CS_2	0.15	0.50
HCl	0.03	0.1 (LC)

3919. Aetiology of Bronchitis. W. B. THOMSON. *Med. World* (London) **92,** 217–20 (Mar. 1960).

Chronic bronchitis, which has a very important influence on the national economy of England, is now regarded as a serious disease, as is evidenced by several recent monographs on the subject. Some aspects of recent studies discussed are: a definition of the disease; the etiology, including the roles of smoking and atmospheric pollution; the role of infection; and the pathology. The author proposes a working definition, for the present, as follows: "A disease characterized by a productive cough on most days for at least three months every year for a minimum of two consecutive years, providing other pulmonary diseases have been excluded." Studies have shown an increasing incidence of bronchitis morbidity and mortality in industrial urban areas when compared with rural areas. A study in 1958 on a fairly homogeneous group of postoffice workers indicated wide geographic variations in the incidence of bronchitis. It was also stated that the variations in incidence could not be explained by any consistent difference in the climate other than fog, suggesting that chronic atmospheric pollution is relatively unimportant except insofar as it predisposes to polluted fog. Whether acute atmospheric pollution actually causes bronchitis remains undecided mainly because the effect on previously healthy young subjects is not clear. (LC)

3920. The Tracking of Pollutants in the Atmosphere. B. WEDIN. *Smokeless Air* (London) **31,** 193–200 (1961).

The purpose of this investigation was to study the horizontal and vertical extension of drifting air pollutants from smoke stacks, slag stacks, and ground furnaces of these industries under different weather conditions, to determine concentrations of sulfur compounds in different places, and from what industry. In order to determine directions, widths, and concentration distributions of aerosol plumes, field tests using fluorescent pigments have been made in different areas. In this article the author describes the work done in Sweden on the dispersal of pollutants in plumes by the release in stack gases of fluorescent pigments, their collection on impactors mounted on aircraft, and counting under ultraviolet illumination. Examples of such surveys are illustrated.

3921. Industrial Health and Air Pollution in Minnesota. F. L. WOODWARD. *Minnesota Med.* **43,** 347–8 (May 1960).

Programs in industrial health, affecting most of the one and one-half million people who make up Minnesota's labor force, place their emphasis on measuring, evaluating, and controlling those environmental factors which may adversely affect the health of people in their places of employment. Despite the increasing industrialization and the continuing use of new materials, the biggest problem facing industrial health workers currently is that of obtaining recognition of the hazardous nature of materials or operations, and of instituting good engineering control practices. It can be expected that at some stage in industrial growth and population, concentration problems of air pollution will occur in a community, with smoke palls, reduced visibility, property deterioration, eye irritation, respiratory difficulties, or even increased morbidity and mortality rates, as indications of this increase in concentration. Within the state of Minnesota there has been considerable complacency about air pollution as a problem. Industrial health and air pollution programs both concern themselves with measurement, evaluation, and control of air contamination. Much engineering know-how is available for the solution of most industrial health problems but much basic information on environmental factors is needed before satisfactory solutions can be found for air pollution problems. It is not too soon to be considering the need of air conservation measures in the State. (LC)

3922. Air Pollution. *C.S.I.R. Research Rev.* (Pretoria) **10,** 64–9 (June 1960).

Although air pollution is not yet as serious in South Africa as it is in some European or American cities, there is proof that in cities like Johannesburg, Pretoria, and Durban, it has reached a stage comparable to that of Portsmouth, Leicester, and Southampton, and that it is not much less than in some parts of London. In 1955 the C.S.I.R. (Council for Scientific and Industrial Research) held a conference in Pretoria at which it was agreed that further investigations of air pollution were necessary. Two subcommittees have been active, one in drawing up a draft Bill for South African conditions and the other drawing up a general program for the research which is considered necessary. The C.S.I.R., in collaboration with the cities of Pretoria, Johannesburg, Durban, and East London, has made regular measurements of smoke and sulfur dioxide and has acquired a considerable amount of information. On Mar. 11, 1960, a conference was held in Johannesburg, at which the Minister of Health stated that the Government would be prepared to contribute to a research fund approximately $5000 a year for a period of 5 years. At a meeting on Apr. 20, 1960 of the Action Committee, which was appointed at the conference, it was agreed that the research program and policy should be directed by the C.S.I.R. under the guidance and advice of a Technical Steering Committee. (LC)

3923. Medical Aspects of Air Pollution; an International Conference held in Vienna, Aug. 29, 1960. **Conference* **1,** 1–20 (Oct. 1960).

An international conference on Medical Aspects of Air Pollution was held at the Imperial Hotel, Vienna, August 29, 1960 in conjunction with the Sixth International Congress on Diseases of the Chest of the American College of Chest Physicians. It was attended by physicians with wide experience in diverse disciplines. The participants described their own observations, interchanged information, analyzed recent statistical, epidemiological and experimental findings, and most important, presented new ideas for research and education. In keeping with the informality of the approach, the discussion is presented in this publication mostly as an informal conversation. The two graphs reproduced include one showing amounts (tons/km.^{2}/month) of dust deposited in major industrial cities of Japan. These figures were: for Tokyo, 21.2; Kawasake, 21.9; Yokohoma, 16.8; Osaka, 23.2; Amagasake, 14.0; Kobe, 10.0; and Ube, 33.3 Only in Ube did the soluble substances consist of more than 25%, with the insoluble substances being, therefore, less than 75%. A second graph presents the comparable degrees of atmospheric pollution in the four cities of Philadelphia, Cincinnati, Los Angeles, and Mexico City, shown as percentage amounts of aliphatic hydrocarbons, aromatic carbon compounds (carcinogenic), and oxidants, as follows:

City	Oxidants	Aromatic Compounds	Aliphatic Hydrocarbons	Total
Philadelphia	23	23	25	71
Cincinnati	11	18	60	89
Los Angeles	12	15	27	54
Mexico City	19	50	20	89

(Note: The graph does not indicate the base for the percentages.) (LC)

3924. A Pilot Study of Air Pollution in Washington, D. C. Department of Public Health, District of Columbia, and U. S. Department of Health, Education, and Welfare, Public Health Service. Dec. 2–8, 1960. 12 pp.

During 1960, a smog episode occurred September 23–27 which was marked by reduced visibility and incidents of eye irritation. Reports from the Beltsville research unit of the Department of Agriculture also have indicated relatively high oxidant levels and instances of smog-type damage to sensitive leafy vegetation. In recognition of the air pollution problem, the D. C. Board of Commissioners on October 26, 1960 assigned overall responsibility for spearheading and coordinating air pollution activities to the Department of Public Health and charged the Department with developing a plan for air pollution surveying, monitoring, and control. As an initial step, it was decided to carry out a pilot study to test air pollution levels and to gain experience in air pollution sampling. Table 2 of the text lists the maximum levels of pollution which were found during the study period. The significant levels of oxidants, nitrogen dioxide, and nitric oxide are indicative of photochemical smog similar to that found in Los Angeles. On December 5 when the oxidant level reached 0.25 ppm., several reports of eye irritation were received. However, the oxidant level did not exceed that set by the California standards during the seven-day sampling period. The maximum level of 0.70 ppm. of nitric oxide reached on December 6 is comparable to the levels reached on smoggy days in Los Angeles and is particularly indicative of the photochemical smog potential of the Washington Metropolitan Area. The California Standard for particulate matter is set as that amount sufficient to reduce visibility to less than three miles at a relative humidity of less than 70%. This standard was exceeded on both December 5 and 6. It was concluded that while this study is a good indication of the general pattern of air conditions in Washington, it must be emphasized that a one-week pilot study of this type can be used only within its contact. Indications of a photochemical smog potential show a clear need for longer term monitoring of atmospheric pollutants to delineate the problem more fully. It would appear that the two major factors are smoke and automotive exhaust fumes. (LC)

BOOKS, MANUALS, SELECTED PUBLICATIONS, SPECIFICATIONS, STANDARDS, TECHNICAL REPORTS

3925. The International Classification of Radiographs of the Pneumoconioses. A. L. C[OCHRANE]. *Tubercle* (London) **40,** 292–6 (Aug. 1959).
The results of the most recent meeting of experts to produce the International Classification of the Pneumoconioses, were published in 1959. Previous meetings of such experts were held in 1930, 1938, and 1950. This most recent meeting had the specific task of studying the results obtained in the application of the Sidney classification of 1950 and of making such modifications as seemed appropriate in order to overcome certain difficulties which had been encountered in practice. Correspondence and interviews with about 120 specialists in many different countries were carried on before the meeting. It appeared in general that the Sidney classification had been widely used in coal mining areas—in particular in the slightly modified form known as the Cardiff/Douai classification—but that it had been little used elsewhere. One of the main criticisms was that the Sidney classification omitted any recognition of what are generally called "linear opacities." The various aspects of the classifications, and some of the changes, are discussed in considerable detail. The point is then raised of whether a committee, meeting for 2 weeks about every 10 years, is the right sort of organization for dealing with the problem. And that it might well be a permanent committee meeting once or twice a year. Possibly this work of medical classification might well be transferred to the jurisdiction of WHO. (LC)

3926. Chemical Analyses of Automobile Exhaust Gases for Oxygenates. C. F. ELLIS. RI **No. 5822,** U. S. Dept. Int. Bureau of Mines, Wash. 25, D. C. 1961. 35 pp.
Contents: Summary. Experimental procedures. Analytical results and discussion. Conclusions. Appendix: (a) The sampling of exhaust gases. (b) The chemical methods of analysis. (c) Some properties of the gasoline used in this work. Illus. References. Tables. The data presented establish the order of magnitude of the concentrations of major oxygenated compounds and classes found in automobile exhaust gases produced under simulated cruise operating conditions. This report presents procedures for chemical analyses of certain oxygenated compounds, procedures for sampling the exhaust gases for these analyses, and the analytical results of some experimental work in which these procedures were used.

3927. The Air Pollution Problem. An Appraisal. W. L. FAITH. Air Pollution Foundation, San Marino, Calif. 1960. 35 pp.
Contents: Defining the air pollution problem. The nature of air pollution. The extent of air pollution. Governmental activities. Nongovernmental activities. Solving the air pollution problem. Appendix. This report does not present specific remedies for all air pollution problems because each locality has its own unique problem, insofar as the relative importance of specific factors is concerned. The final chapter presents a basic guide to help others avoid the pitfalls that have plagued many communities. The prerequisite to recognition and sound solution of all air pollution problems is detailed factual knowledge of the physical, chemical, and biological activities of airborne material. The appendix shows a list of 64 scientific research problems awaiting investigation.

3928. Effect of Exhaust Gas Recirculation on Automotive Ring Wear. R. D. KOPA, R. G. JEWELL, and R. V. SPANGLER. Rept. **No. 61-20.** Univ. of California, Los Angeles, Calif. 1961. 34 pp.
Contents: Experimental facility. Results of the piston ring wear experiments. Piston ring wear reduction phenomena of exhaust gas recirculation. Auxiliary experiments: (1) The effect of water induction on ring wear. (2) The effect of recycle exhaust gas temperature on ring wear. (3) Effect of exhaust gas recirculation on engine deposits. The experiments were performed on a test facility especially designed for evaluation of lubricating oils, fuels, and additives, for their effect on piston ring wear. An attempt was made to explain experimentally and theoretically, the surprising ring wear reduction resulting from the use of exhaust gas recirculation. This report also presents the description of the experimental facility.

3929. Evaluation of Radioactive Fallout. L. P. SALTER. Final Rept. NSEC-**30,** U.S.A.E.C. AT(30-1)-2420. 1960. 38 pp.
Contents: Introduction. Fallout pattern during precipitation: Discussion. Experimental procedures. Results. Discussion of results. Conclusions. Ce-144 and Sr-90 in nuclear debris: Ce-144 and Sr-90 in the atmosphere. Ce-144 and Sr-90 in Pittsburgh precipitation. Relative solubility of Ce-144 and Sr-90 in rainwater. Conclusions. Appendixes: Sample collection procedures. Meteorological report. Radiological procedures. Figures. References. Tables. This report summarizes work performed from July 1, 1959 to June 30, 1960. The objectives of the work were to develop data on the content of nuclear debris in the atmosphere and in precipitation which may be of assistance in studying the mechanisms of the deposition of radioactive fallout. A study was made of the fallout pattern during a rainfall which occurred during the period Jan. 10–12, 1960 in the Pittsburgh area. Each of the duplicate samples collected during 9 intervals was separately assayed by an adaptation of the procedures used for the analysis of Pittsburgh pot collections and individual rainfalls, and upper air samples. Sr-90, Ce-144, and gross β activity were analyzed. A summary of data on the air masses over Pittsburgh, the rate of precipitation as a function of time, and the activity concentration as a function of time are shown in figures 2, 3, and 4.

3930. A Study of the Wind Profile in the Lowest 400 Feet of the Atmosphere. I. A. SINGER and CONSTANCE M. NAGLE. Progr. Rept. **No. 8,** Sept. 16, 1960–Jan. 15, 1961. Brookhaven Natl. Lab., Upton, N. Y. 1961. **$0.75.** 28 pp.
This report continues the analysis of errors in predicting upper level wind speeds from speeds at a lower reference level by using an unweighted predictor of varying averaging length and relative displacement in time. In previous reports this analysis was always a "forecast," with the mean at the prediction level. For this report the same data were used to make a "hindcast," and the results were evaluated. A detailed study was completed of the variation of p, obtained from the power low, with solar time and wind speed. In previous analyses it was noted that the mean wind speed does not always increase with height. An outline is given of the theoretical approach to be used in evaluating this condition. Test procedures which evaluate the effect of displacing the reference level horizontally are described. A 50-ft. portable mast will record data at distances up to 750 ft. from the meteorological tower. (Authors' abstr.)

3931. Symposium on Air Pollution Control. ASTM Tech. Publ. **No. 281,** American Society for Testing Materials, Phila., Pa. 1960. **$1.50.** Members **$1.20.** 44 pp.
Contents: Air pollution potential of California coastal climate. Wind and weather summaries for chemical plant design and air pollution control. Fluorescent dyes as airborne tracer materials. The colorimetric determination of formaldehyde and methanol from combustion sources. Determination of gaseous and particulate inorganic fluorides in the atmosphere. The symposium was sponsored by Comm. D 22 on methods of atmospheric sampling and analysis as a part of its continuing program toward solution of air pollution problems by exchange of information and establishment of standards for analysis of the atmosphere.

3932. Air Pollution (Conference Report). Publ. Health Repts. 75, 1173–89 (Dec. 1960). Reprints available on request from the Air Pollution Division, U.S.P.H.S., Washington, D. C.
The Third Air Pollution Research Seminar, sponsored by the U. S. Public Health Service, was held in New Orleans on Mar. 22–24, 1960. Short summaries of the 81 papers given at the seminar are presented here. They are grouped under the subject headings of international aspects, sampling and identification, meteorology, pulmonary physiology, effects of air pollution, engineering, environmental levels of pollution, automotive exhaust research, chemistry, and community studies. Since most of the authors have published, or are in the process of publishing, complete accounts of their work, the full proceedings of the seminar will not be published. It is suggested that individual authors be contacted directly for more detailed information on specific projects. (LC)

3933. Air Pollution from Alfalfa Dehydrating Mills. U. S. Department of Health, Education, and Welfare, Public Health Service. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. 1960. Tech. Rept. **No. A60-4,** 25 pp.

In cooperation with the Kansas State Board of Health and the American Dehydrators' Association, the Air Pollution Engineering Program of the U. S. Public Health Service conducted an evaluation of atmospheric emissions from alfalfa-dehydrating mills. This report discusses the quantity and size distribution of dust discharged to the atmosphere from these mills, as determined by a study of a group of representative plants in Kansas and Ohio. It also discusses dust collection practices at typical plants and the relationship between these dust collection practices and the protein and carotens (pro-vitamin A) content of the meal produced. Dehydrated alfalfa is a meal product dried rapidly by artificial means at temperatures above 210°F. The meal is used for animal foods. A typical plant operates 24 hours a day, 7 days a week, during the normal crop season from late April or early May to late October. Practically all of the dryers are of the direct-fired, rotary type, with the products of combustion leaving the combustion chamber of the furnace at a temperature in the neighborhood of 1800–2000°F. The alfalfa is chopped and wet as it is fed into the dryer. People living in the vicinity of alfalfa-dehydrating plants have often objected to the dust emissions because of the soiling effect of the settled alfalfa meal dust, and to the odors arising from volatile matter driven off the alfalfa with the moisture and the combustion products emitted to the atmosphere. Some of the complaints allege damage to health, allergic reactions, and discomfort. One plant manager estimated that originally from 6–7% of the product input was lost to the atmosphere as dust. For a typical plant with five individual exhaust locations, each with about the same rate of dust discharge, four are amenable to control by utilizing standard cloth filter bag collectors. Thus a reduction of about 80% of the pollution may be affected by relatively simple and economic means. In many locations this reduction may be adequate to eliminate local nuisances without attempting to control the moist, high temperature effluent from the fifth source—the primary cooling cyclone. (LC)

3934. Atmospheric Emissions from Petroleum Refineries. A Guide for Measurement and Control. U. S. Dept. H. E. W. Div. Air Poll. Publ. **No. 763,** 1960. $0.30. 56 pp.

Contents: Petroleum refining. Atmospheric emissions from oil refineries. Control of emissions from oil refineries. Appendixes. Illus. References. Tables. This manual supplements the Joint Project reports and stresses the use which can be made of the methodology and results in estimating emissions from refineries. It also includes a discussion of equipment and processes, and details on the sources, magnitude of emissions, and methods of control in effect in Los Angeles County refineries.

3935. Pneumoconiosis Abstracts, Vol. III, 1951–55. Bureau of Hygiene and Tropical Diseases, London. Pitman Medical Publishing Co., Ltd. London. 1959. 376 pp.

The first two volumes of abstracts, as well as the current Volume III, were collected from the publications of the *Bulletin of Hygiene (London)*. The volumes are indexed both by author and subject. The first volume covered 13 years of publications with an average of 24 pages a year; the current volume covers five years with an average of 71 pages. The wealth of material brings to light, and in some instances helps to clarify, some of the controversial areas of information about pneumoconiosis and related dust diseases of the lungs. Some of the controversial areas are: the role of phagocytosis in clearing the alveoli of dust; the use of aluminum therapy; and the physiochemical mechanism for the fibrogenic action of silica. Noted is the establishment of an international system of classifying the severity of pneumoconiosis from x-ray pictures. Similar agreement on the use of the terms silicosis, pneumoconiosis, silicotuberculosis, etc., has not yet been attained. Treatment of pneumoconiosis by the oral administration of cortisone failed generally to give any beneficial effects, but there are accounts of therapeutic improvement in silicosis after using various drugs. The latter is particularly true of the anti-tuberculosis drugs when the two disease conditions are associated. A strong case is made against the use of BCG vaccination of silicotics since the presence in the lungs of silica might result in the BCG becoming virulent. The theory that very fine particles, below 0.1 μ, are largely responsible for silicosis rather antedated the period of this third volume. There are also references to the success of dust control by water sprays, and the use of wetting agents. Dust sampling methods during this period benefitted from the results of several laboratory studies of the performance of dust sampling instruments. (LC)

3936. [(Proceedings of) 13th All-Union Conference of Workers in Sanitation, Epidemiology. Microbiology, and Infectious Diseases. Moscow, 1956. v. 1, Hygienic Problems.] Vsesoi͡uznyĭ S'ezd Gigienistov, Epidemiologov, Mikrobiologov i Infektsionistov. [Doklady] 13th. Moscow. 1956. v. 1, Voprosy gigieny. Moscow. Medgiz, 1959. 728 pp.

Among the more than 250 papers presented at this Conference were several having to do with the various aspects of air pollution. Both V. A. Ri͡azanov (p. 76–83) and V. K. Navrot͡skii and Z. B. Smeli͡anskii (p. 95–102) discussed problems of hygienic standards for use in control of atmospheric air pollution. I͡U. D. Lebedev, A. S. Perot͡skai͡a and L. F. Glebova (p. 176–182) considered such control in populated areas, especially in industrial cities. Recent conditions and immediate tasks in sanitary studies of control are considered by M. G. Gol'dberg (p. 182–187). Control of atmospheric air pollution in various areas or industries is considered by N. M. Tomson (p. 187–190) for Leningrad, by L. V. Timofeeva (p. 190–192) for the sulfur dioxide problem around copper smelting installations of the Central Urals, and by K. V. Ki͡iamov (p. 194–196) for the celluloid and aluminum industry. (LC)

EFFECTS OF AIR POLLUTION

3937. Anosmia in Alkaline Battery Workers. R. G. ADAMS and N. CRABTREE. *Brit. J. Ind. Med.* (London) **18,** 216–21 (July 1961).

The sense of smell of 106 alkaline battery workmen exposed at their work to cadmium and nickel dust has been compared with a control group of 84 men matched for age. The battery workers reported significantly more anosmia than the control, 15% to 0, and less in the phenol smelling test, 27.3 to 4.8%. Cadmium proteinura was found in 17 of the battery worker, 11 of whom showed virtual anosmia. Figures of recent concentrations of cadmium and nickel in the atmosphere are given. The noses of 85 battery workers and 75 controls were examined. Signs of nonspecific chronic irritation were more frequent in the battery workers but no significant relationship was established between this appearance and the presence of anosmia. It is concluded that the anosmia is due to exposure to cadmium or nickel dust or a mixture of both. (Authors' abstr. cond.)

3938. Effect of Low Concentrations of Carbon Dioxide on Photosynthesis Rates of Two Races of Oxyria. W. D. BILLINGS, E. E. C. CLEBSCH, and H. A. MOONEY. *Science* **133,** 1834 (June 9, 1961).

Alpine plants of *Oxyria digyna* have higher apparent photosynthesis rates at various carbon dioxide concentrations than arctic, sea level plants of the same species. The volumetric concentration of atmospheric CO_2 in ppm. varies little with altitude. On the other hand, the partial pressure of Co_2 in the atmosphere decreases with altitude and with lowered total atmospheric pressure. The data presented appear to give substance to the hypothesis that low CO_2 pressures may limit the upward distribution of plants of certain species and races on high mountain ranges.

3939. [Byssinosis.] Oorspronkelijke stukken. A. BOUHUYS. *Nederlandsch Tijdschrift voor Geneeskunde* (Amsterdam) **103,** 2356–60 (Nov. 21, 1959).

Note: Similar experimental results were reported in APCA no. 3171. (LC)

3940. Respiratory Disease of Mushroom Workers. Farmer's Lung. L. S. BRINGHURST, R. N. BYRNE, and J. GERSHON-COHEN. *J. Amer. Med. Assoc.* **171,** 115–18 (Sept. 5, 1959).

Clinical observations of 16 patients were collected to exemplify a possible new disease entity. Each was a Puerto Rican migratory worker engaged in the handling of compost used as soil for growing mushrooms in an area in Pennsylvania. The disease has not, as yet, been observed or identified in other persons. Immunity was not conferred by a single episode or successive episodes. The diseases recurred with reexposure. Treatment was non-specific and supportive. Removal of contact with the compost was necessary for cure. The consistent findings were respiratory signs and symptoms, characteristic roentgenographic appearance of the lung fields, eosinophil count elevation, nationality of the patient, and contact with the compost. The natural pattern of the disease resembles that of "farmer's lung" and "silo-filler's disease." The etiology remains undetermined. (Author's summary—LC)

3941. Toxicology of Selenium and Tellurium and Their Compounds. E. A. CERWENKA, JR. and W. C. COOPER. *Arch. Environmental Health* **3,** 71–82 (Aug. 1961).

This review presents a comprehensive survey of the toxicological properties of selenium and tellurium and their compounds. Recent studies have indicated that selenium has an important role in animal nutrition and may be of particular value in the treatment of a number of deficiency diseases. Selenium and its compounds have a toxicity to humans which varies widely. While the toxicity of elemental selenium is rather low, inhaled selenium dust and fumes have given rise to irritations of the respiratory tract. Considerably less is known about the toxic effects of tellurium than about selenium, although tellurites seem to be an exception to this rule. The toxicity of hydrogen telluride resembles that of hydrogen selenide in a number of respects. The Mac. for tellurium in air is given as 0.01 to 0.1 mg./m.^{3}. Relatively little is known about the toxicity of tellurium, and more investigations are needed, particularly regarding the long-term effects of low doses of tellurium and its compounds. 67 references.

3942. Observations on the Pathogenesis of Silicosis by Means of the Diffusion Chamber Technique. A. G. HEPPLESTON, K. A. AHLQUIST, and D. WILLIAMS. *Brit. J. Ind. Med.* (London) **18,** 143–7 (Apr. 1961).

An attempt has been made to determine whether the diffusion chamber technique can be used to decide the validity of the silica solubility theory of the pathogenesis of silicosis. Small chambers were constructed from membranes of a pore size which allowed free passages of colloidal silicic acid and tissue fluids but which prevented the entry of host cells and the exit of the larger silica particles. Significant fibrosis failed to develop around chambers containing 5 different forms of silicon dioxide when inserted subcutaneously and intraperitoneally in rats and rabbits. All 5 forms of silica were actively fibrogenic when brought into direct contact with peritoneal tissues. However, *in vitro* experiments suggest that colloidal silicic acid, the form which may be involved in silicotic fibrosis, does not escape from the chambers. Thus the biological results obtained by this technique do not necessarily invalidate the silica solubility theory of the pathogenesis of silicosis. (Authors' abstr.)

3943. Epidemiologic, Experimental, and Histological Studies on Metal Cancers of the Lung. W. C. HUEPER. *Unio Intern Contra Cancrum Acta* (Louvain) **15,** (2) 424–36 (1959).

Epidemiologic studies of regional and occupational lung cancer frequency rates indicate that metallic atmospheric pollutants seem to be, or actually are, involved in the causation of these cancers and may account for a part of the definite variations in these rates found for different communities and occupational population groups. The histologic, hyperplastic, and neoplastic lesions elicited in the lungs of experimental animals by nickel and chromium-containing compounds are similar or identical with those seen in man exposed to the same and similar inorganic carcinogenic dusts, fumes, and vapors. The cancerous reactions observed in animals and man include carcinomas of the squamous cell-, round cell-, and adenocarcinomatous-types. Animals exposed to nickel and chromium exhibit, moreover, sarcomatous reactions. Since, from a review of the literature, there is abundant human and experimental evidence indicating that the same exogenous carcinogen is capable of producing cancers of different histologic types, the recently advanced claim that squamous cell- and round cell-carcinomas of the human lung are predominantly or almost exclusively caused by cigarette smoking has no sound scientific or factual basis. (Author's summary, modified—LC)

3944. Lung Cancer; Air Pollution as a Cause. W. C. HUEPER. *Amer. J. Nursing* **61,** 64, 66–69 (Apr. 1961).

A critical appraisal of the total epidemiologic, industrial, medical, and experimental evidence accumulated during the past 50 years indicates that industrial and industry-related pollutants of the atmosphere, especially in urban regions, have played an important part in the cause of cancers of the lung and in their remarkable increase during the period surveyed. The marked irregularity of the epidemiologic pattern of lung cancers observed in many countries of the Western World militates against the claim that a single causal factor of more or less uniform distribution can plausibly account for the rise in frequency of lung cancers. Cigarette smoking, while likely as being a direct or indirect respiratory carcinogen, therefore, cannot justly be incriminated for any major portion of the recent development. Some causal factors of pulmonary carcinogenesis are apparently still unknown and some of these may be introduced into the body by other than the respiratory route. An effective future control of lung cancer hazards by preventive measures is a practically feasible procedure if available factual knowledge is properly utilized. For maximal effectiveness of such procedures proper consideration must be given to the special conditions of exposure and pollution prevailing in individual communities. (Author's conclusions—LC)

3945. Air Pollution and Respiratory Diseases. A. J. LAIDLAW. *Public Health* (London) **75,** 25–30 (Oct.-Nov. 1960).

The difficulties and inaccuracies involved in using mortality figures obtained from death certificates or the national sickness records in an assessment of mortality or morbidity from air pollution are discussed. The author then describes a survey of morbidity in general practice which was carried on from May 1955 to May 1956 by 221 general practitioners. The survey was organized by the College of General Practitioners and the General Register Office. About 360,000 patients were involved and some 1,500,000 consultations were held. Currently one volume of a book on "Morbidity Statistics in General Practice" has been published and two others are in preparation. There are now 169 pages of statistical tables available to research workers. The percentage distribution of diagnostic groups indicated the respiratory group to be the largest (23%); acute nasopharyngitis had the highest patient consulting rate. Tuberculosis, acute respiratory infections, bronchitis (about 40%), and pneumoconioses were more prevalent in urban than in rural areas. The air pollution rates for similar size towns vary considerably. Towns with populations of 50,000–100,000, such as Burnley and Exeter, have respective air pollution deposit indices of 494 and 96 and smoke indices of 21 and 8. In towns with a population over 100,000, Salford has a deposit index of 731 and a smoke index of 36; in Southampton, these figures are 204 and 11. In these cities cited the death rates for bronchitis, pneumonia, lung cancer, and phthisis were higher in the more polluted towns and the morbidity rates are probably also higher. To see this whole problem in true perspective a large number of general practitioners would be required to represent all areas of the country and record respiratory morbidity for many years. The College has shown that this could be done accurately. (LC)

3946. [Experimental Research on the Etiology of Chronic Cholesterol Pneumonia. II. Bronchopneumonia Caused by Toxic and Nontoxic Substances in Normal and Hypercholesteremic Rabbits.] Richerche sperimentali sull 'etiologia della polmonite cronica colesterolica. Nota 2—Broncopolmomiti da sostanze tossiche e non tossiche in conigli normo- e ipercolesterolemici. E. PANSA, F. ROLFO, and G. MAGGI. **Arch. Chir. Torace* (Florence) **14,** 143–63 (Jan.–Mar. 1960).

Rabbits were made hypercholesterolemic (levels of 1000–1200 mg./100 cc.) by the intravenous injection of Triton W R 1339, in doses of 200 mg./kg. every 4–5 days. Into each of several groups of these hypercholesterolemic rabbits, or of normal rabbits, was injected intratracheally a solution of either sterile culture-broth (5.0 cc.), staphylococcic toxin (0.08 cc. in 3.0 cc. of physiological solution) or of Triton (5 cc. of a 10% solution). In the normal rabbits a desquamative bronchopneumonia with scattered foci and a mean accumulation of cholesterol, was noted. In the cholesterolemic animals, the condition developed with much larger, confluent foci, big deposition of cholesterol, and a tendency to chronicity and fibrosis as in human pneumomitis of the cholesterol type. In test animals with normal cholesterol levels, there was no cholesterol in the lungs: the rabbits maintained a hypercholesterolemia for a long while, showed only scarce and scattered drops of it. The results obtained permit the authors to state that many inflammatory stimuli may cause, in certain conditions, an accumulation of cholesterol in the lungs. What should confirm the hypothesis, already proposed in an earlier work by two of the authors, is that the cholesterol pneumonia (foam cell pneumonitis) is a disease which has multiple etiology but a single pathogenic mechanism: viz., an impaired lipodieretic function provoked by a local reduction of oxygen, due to the stopping up of many alveoli by desquamated cells. No influence could be attributed to differences in stimuli. (Authors' summary—LC)

3947. Pulmonary Histologic Reactions to Inhaled Fiberglas-Plastic Dust. G. W. H. SCHEPERS. *Amer. J. Pathol.* **35,** 1169–87 (Nov.-Dec. 1959).

Investigations were made using dusts derived from both a $CaSO_4$-filled sheet Fiberglas-plastic and a $CaCO_3$-filled molded Fiberglas-plastic for the purpose of studying the lesions provoked by inhalation of either dust. In the first group, experiments were made on 20 rats, 64 guinea pigs, and 9 rabbits which were exposed for periods up to 9.3 months to aerosol concentrations of pulverized $CaSO_4$-filled plastic averaging 283 million particles per cubic foot of air. In the second group of experiments, using $CaCO_3$-filled plastic, 36 rats, 65 guinea pigs, 12 rabbits and 5 monkeys were exposed at an average concentration of 338 million particles per cubic foot of air for periods up to 25 months. The results of both experimental groups are as follows: The lungs of the rabbit proved relatively resistant to both varieties of inhaled Fiberglas-plastic dust. Of the 4 varieties of animals investigated, the histological reactions in the monkey were probably the most significant. Marked peribronchiolar, perivascular and perilymphatic cellular infiltrations occurred within 6 months after Fiberglas-plastic exposure. A characteristic pneumoconiotic lesion, which did not include a fibrotic component, was induced upon exposure of the guinea pigs to $CaCO_3$-filled dust. In addition, significant involvement of the bronchioles and alveolar ducts occurred. All these reactions were reversed on cessation of dust inhalation. The pulmonary responses of guinea pigs to $CaSO_4$-filled dust were comparatively insignificant. In the rats, inhaled $CaCO_3$-filled dust provoked a very limited, reversible, nonspecific reaction. However, the substitution of $CaSO_4$ for $CaCO_3$ as the filler reduced the effect of the inhaled dust. Because of the diversity of reactions evoked in the four species of experimental animals, a measure of uncertainty as to which should be extrapolated to man is indicated. (LC)

3948. [Increased Resistance of Silicotics to Asian A 1957 Virus Infection.] Observazioni sulla frequenza dell 'influenza da virus A/Asia 1957 nei silicotici. E. C. VIGLIANI and M. FINULLI. *Med. lavoro* (Milan) **50,** 517–22 (Aug.–Sept. 1959).

The increased resistance to Gram-negative bacterial infections observed in experimental silicosis in the mouse, led to investigations as to whether also in human pathology silicosis is associated with increased resistance to some infections. Frequency of Asian influenza was compared in silicotic and non-silicotic subjects. Among 123 silicotic patients hospitalized in the "Clinica del Lavoro" from September 1957 to April 1958, only 5 cases of influenza were seen; in 100 control patients in the same Clinic for the same period, 20 cases were observed. A study of the case histories of 334 silicotic patients brought out the fact that there were 35 cases of influenza (10.5%), while 41% of the working population in the province of Milan were affected by the influenza pandemic. In a convalescent home in Como only 2 cases of influenza were seen among 281 silicotic patients hospitalized for an average period of 44 days each during September 1957–April 1958. Out of 39 non-patient employees having contact with the patients, 22 had influenza. These and other incidences of increased resistance of silicotic patients to Asian influenza were found to be very similar to the increased resistance observed in tubercolitic patients. The increased resistance of silicotic patients to Asian A 1957 virus appears to be due to the adjuvant action of quartz, which consists of an activation of the reticulo-endothelial system and increased antibody response to antigens. The adjuvant action of quartz is explained with the hypothesis that quartz, killing the macrophages by which it is phagocytosed, liberates from them endotoxic lipopolysaccharides. (Authors' summary, modified—LC)

3949. Chronic Carbon Monoxide Poisoning. *New Engl. J. Med.* **261,** 1248–9 (Dec. 10, 1959).

In this review it is noted that carbon monoxide poisoning in the acute form has long been recognized but that the slower and more insidious form of intoxication, with intermittent symptoms and vague relations to the sources of poisoned atmosphere, is only now being brought into prominence. The basic facts were mostly gathered in Europe and about 10 years ago were published in a Danish monograph by Grut [Copenhagen, Ejnar Munksgaard, 1949]. Recently the subject has been activated with reports from health authorities in the state of Connecticut. Carbon monoxide poisoning in a chronic form, because of psychiatric and neurologic symptomatology, is frequently incorrectly diagnosed as epilepsy (see APCA 3185). It is possible that some people are more susceptible to this form of attack than are others, but the timing of attacks, their nature, the mental changes, and the intermittent symptoms should lead to a diagnosis in all persons exposed to carbon monoxide whether inside or out-of-doors. (LC)

3950. Smoking and Lung Cancer. *J. Amer. Med. Assoc.* **171,** 2104 (Dec. 12, 1959).

"A summary of pertinent data relating to smoking and lung cancer appeared in this Journal in November [APCA #2913]. Written by Dr. Leroy E. Burney, surgeon general of the Public Health Service, the report documents the major researches and identifies the Public Health Service with those who consider that the evidence to date implicates smoking as the principal etiological factor in the increase in lung cancer. A number of authorities who have examined the same evidence cited by Dr. Burney do not agree with his conclusions. Although the studies reveal a relationship between cigarette smoking and cancer that seems more than coincidental, they do not explain why, even when smoking patterns are the same, case rates are higher among men than among women and among urban than among rural populations. Neither the proponents nor the opponents of the smoking theory have sufficient evidence to warrant the assumption of an all-or-none authoritative position. Until definitive studies are forthcoming, the physician can fulfill his responsibility by watching the situation closely, keeping courant of the facts, and advising his patients on the basis of his appraisal of those facts. The Public Health Service can best meet its obligations by collecting and disseminating data from all sources and making known to the health and medical professions its own evaluation of such data." (Quoted in full—LC)

LEGISLATION, PLANNING, ZONING

3951. Air Pollution Potential Advisory Service for Industrial Zoning Cases. M. BREIVOGEL, S. S. GRISWOLD, A. HASEGAWA, and J. R. TAYLOR. *J. Air Poll. Control Assoc.* **11,** 327–35 (July 1961).

The procedure now followed in reviewing industrial zoning transactions has been influenced by the time required for investigation of the cases, and the presentation of the information at the official public hearing. Technical assistance to planning commissions concerning the air pollution potential of industrial uses is the 1st step in establishing air pollution planning relationship. The types of zoning cases are classified as specific single or indefinite area sources. The specific single sources include the exception, variance, special permit, and conditional use types of zoning cases. The areas sources include the establishment of industrial zoning classification and the application of the industrial zones to specific locations. The single source can be evaluated from an engineering approach while the area source can be evaluated from a meteorological approach. The air pollution recommendations to alleviate future individual emissions can be incorporated as conditions of operation in the zoning program.

LIST OF NEW JOURNALS

Abst. Soviet Med. Pt. B.-Clin. Med.
Abstracts of Soviet Medicine
(Pt. B-Clinical Medicine)
Publ. by
Excerpta Medica Foundation,
New York City or Amsterdam

Acta Oto-laryngol.
Acta Oto-laryngologica
Karlavägen 41,
Stockholm, Swed.

Akad. nauk S.S.S.R., Doklady
Akademiia nauk S.S.S.R.
Podsosenskii per., d 21
Moscow, B-64,
S.S.S.R.

Arch. Chir. Torace
Archivio di Chirurgia del Torace
Sansoni Edizioni Scientifiche,
Florence, Italy

Biul. Inst. Med. Mor. Gdansku. (Bull. Inst. Marine Med. Gdansk)
(Gdansk, Poland)
Biuletyn Instytutu Medycyny Morskiej w. Gdansku (Bulletin of the Institute of Marine Medicine in Gdansk.)
Hiberna St.,
Gdansk, Poland

Bull. Natl. Hyg. Lab.
Bulletin of National Hygiene Laboratory
Tamagawa Yoga-Machi
Setagaya-Ku,
Tokyo, Japan

Cesk. otolaryngol.
Ceskoslovenska otolaryngologie
Statni zdravotnicke nakladatelstvi,
Prague, Czech.

Cincinnati J. Med.
The Academy of Medicine of Cincinnati
The Academy Journal Publishing Co.
152 E. 4th St.,
Cincinnati, Ohio

Conference
Conference
Science Information Bureau, Inc. Publ.
34 E. 51st St.,
New York 22, N. Y.

Energetika
Energetika
Vydava Ministerstvo Energetiky a Vodniko Hospodarstvi,
Prague, Czech.

Eng. Progr. Univ. Florida
Engineering Progress at the University of Florida
Engineering and Industrial Experiment Station
University of Florida,
Gainesville, Fla.

Giessereitechnik
Giessereitechnik
VEB Verlag Technik,
Berlin C2, Ger.

Health Educ. J.
The Health Education Journal
Publ. by
The Central Council for Health Education
Tavistock House, Tavistock Sq.,
London W C 1, Eng.

Maryland State Med. J.
Maryland State Medical Journal
(The Medical and Chirurgical Faculty of the State of Maryland)
1211 Cathedral,
Baltimore 1, Md.

Nederlandsch Tijdschrift voor Geneeskunde
Nederlandsch Tijdschrift voor Geneeskunde
Jan Luykenstroat 5,
Amsterdam, Neth.

Nubila
Nubila (Rivista di fisica delle nubi)
Edita a Cura dell'Unione Nazionale Antigrandine
Via Bolliciai, 17,
Verona, Italy

Predel'no-dopustimye kontsentratsii atmosfernykh zagriaznenii
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Medgiz,
Moscow, USSR

Science Repts. Res. Inst. Tohoku Univ. Ser. C
Research Institute of Tuberculosis and Leprosy
Tohoku Univ.,
Sendai, Japan

Surg. Forum
Surgical Forum
American College of Surgeons,
Chicago, Ill.

Tubercle
Journal of the British Tuberculosis Assn.
Staples Holdings, Ltd.
Mardeville Place,
London, Eng.

Wasser Luft u. Betrieb
Wasser Luft und Betrieb
Krausskopf-Verlag,
Wiesbaden, Ger.

APCA ABSTRACTS
Vol. VII, No. 5 October 1961
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LETTERS to the EDITOR

Honorable Abraham A. Ribicoff
Secretary of Health, Education, and Welfare
Washington, D. C.

Dear Mr. Ribicoff:

I note by an article in the *Washington Post* under the by-line of Morton Mintz that you have given the automotive industry an ultimatum either to put piston blow-by control on the engine oil filter breather pipe or face legislative action.

If you really want to get rid of toxic, eye-burning, ionized, nitric oxide-laden atmosphere in our cities, you should have given the ultimatum to General Motors to detoxify and de-ionize the 954 ppm of oxides of nitrogen which their research engineers, F. G. Rounds and H. W. Pearsall, have found in a 200 hp two-cycle diesel engine under load, which is the same type and horsepower as the General Motors diesel engine used on General Motors diesel buses in city transit service in our large cities such as New York.

To disprove this phony cause for smog, concocted by General Motors engineers and presented to the Society of Automotive Engineers, I have bought a 10 hp Wisconsin gasoline engine which has the gases that leak by the reciprocating piston of the gasoline engine (known as blow-by) connected to the engine carburetor intake. By this construction, any gas which leaks by the piston into the engine crankcase must again go through the engine power cycle and ultimately out the engine exhaust manifold. Taking the exhaust of this engine which has no piston blow-by going into the ambient air, and putting the exhaust of this gasoline engine into a tank of 14 liters of water for one hour, demonstrated that no acid was absorbed in the water, because the pH was unchanged. The gasoline exhaust, including piston blow-by, therefore, contained no acid gas that could be absorbed or hydrolyzed by the human lungs.

While carbon monoxide is absorbed by the human blood 300 times faster than is oxygen, it does not injure lung tissue when passing in and out of the blood through the alveoli, the semi-permeable membrane that lets oxygen into the blood and carbon dioxide out into the lungs to be exhaled. (The heart cannot pump blood that is thickened by breathing high concentrations of carbon monoxide, but otherwise it is not toxic.)

In 1949 and 1950, when General Motors diesel engines were put on the Idarado mine locomotives, the miners working in the Idarado mines thought it was carbon monoxide in the diesel exhaust that was causing miners to be picked up dead in the mine and making them fall down raises to their death. To satisfy the miners, in April, 1951, the Colorado Department of Public Health, among other things, took blood samples of the diesel locomotive operator and of a mill man who had never been in the mine, and the carbon monoxide was higher in the blood of the latter than it was in the blood of the diesel mine operator. The Department also took samples of the mine air at various places and found over 100 ppm of oxides of nitrogen in the mine air at several sampling stations. This, they failed to tell the miners or the management—presumably out of deference to the Bureau of Mines, who said that there were no harmful parts in GM diesel exhaust. General Motors, which then was selling diesel buses in Los Angeles, which sales might have been prohibited or abandoned altogether if it had been known that the General Motors diesel

PRESIDENT'S PAGE

GROWTH OF APCA PRESENTS CHALLENGE

Growth of any organization entails change. APCA is no exception. Only a few years ago, the Smoke Control Association of America became APCA, and the goals of the organization broadened. Now we are in the midst of further change. Transactions of annual meetings have progressed through the quarterly *Air Repair* to a bi-monthly journal to the present monthly *Journal*. Domination of the organization by control officials was voluntarily surrendered by the control officials themselves. Now our by-laws call for a control official as President only every other year. No longer does APCA have second-class members.

As your President, I feel a deep sense of responsibility to make the transition as orderly and as noncontroversial as possible. Undoubtedly, two years from now an industrial representative will be President. We will have gone through the transition period.

Although there is transition in the government of APCA, our goal remains the same, clean air by reasonable methods. To achieve this goal we need the support and co-operation of all members. We need even broader representation from every segment of society. Every individual and corporate member of APCA can help by preaching the gospel of APCA to his colleagues and urging others to join the only international organization with the sole objective of clean air.

We are well represented by control officials, but many members of control organizations do not belong to APCA. Our control members can urge them to join. Some segments of industry are very conspicuous by their absence from our rolls. Two that come to mind are the automotive industry and the food industry. Some of our present members can be particularly helpful in aiding us to obtain broader representation.

There is room in APCA for more representatives of the public-at-large. Many interested persons in this category have limited their activities to local problems. Perhaps they can achieve their goals more readily by joining with their professional colleagues. For APCA, above all, is a forum for all viewpoints as long as the discussion is consistent with our goal. It is conceivable that the research, consultant and governmental category on the APCA Board of Directors could be expanded to include a public representative.

Internal problems naturally will arise as our membership broadens. We will need a larger headquarters group, a broader coverage in our *Journal*, more support of advertisers. But basically we can only do what our membership supports and promotes. The growth of APCA is a challenge to each of us. The suggestions of each individual and corporate member are solicited. Together we can make our transition period one of real growth.

engine exhaust was loaded with toxic oxides of nitrogen that killed men in the Idarado mine.

The Idarado mine air samples for oxides of nitrogen and the blood samples from the Idarado workmen were all taken in April 1951.

The carbon monoxide blood samples were taken to satisfy C. L. Hamblin, business representative of the miners' union, who contended that it was carbon monoxide in the diesel exhaust that was killing the miners. (All cigarette smoke contains carbon monoxide that enters the blood.)

To humiliate Mr. Humblin, several mine safety officials made great sport of the fact that the mill man who had never been in the mine had more carbon monoxide in his blood than did the diesel mine locomotive operator.

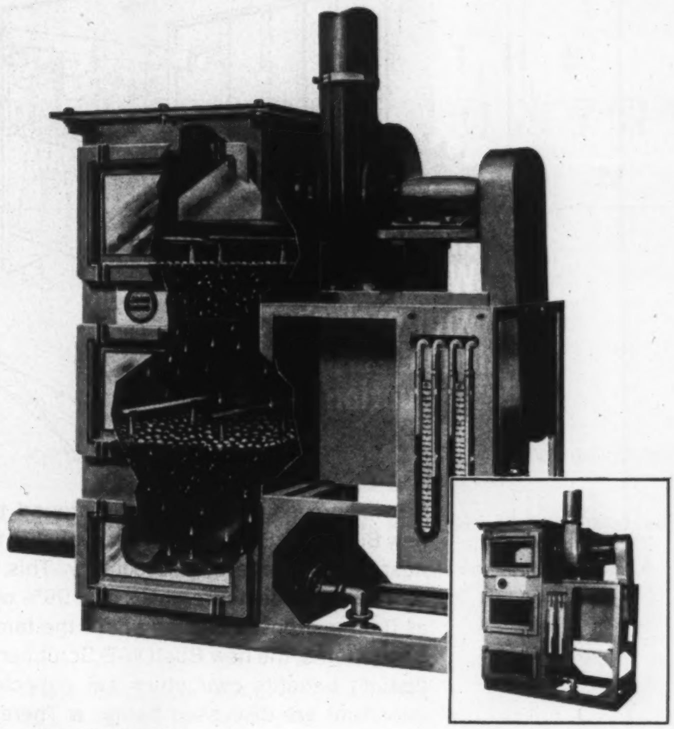
While these mine safety officials, both state and federal, told the story often to bolster their argument that there were no harmful parts in diesel exhaust, they did not, at the time, tell the miners or the management that the mine air was five times more toxic with oxides of nitrogen than it should have been. It was only when Jack Torrey was cross examined in December of 1952, 21 months later, that he was forced to admit the truth. I can still see the look of despair on the face of Fred Wise, the General Manager of the Idarado mine, who was then wan and emaciated, when Jack Torrey was forced to admit that the Colorado Department of Public Health had let him and his men work for 21 months in air that was five times more toxic than it should have been. Fred Wise died a few months later.

It does not take much imagination to visualize what would have happened to the sale of General Motors diesel buses for city transit service if the Colorado Department of Public Health had shut the Idarado mine down in April, 1951, which they were legally under obligation to do, since the air was five times more toxic from General Motors diesel engine exhaust than the then 25 ppm maximum allowable concentration; now it would be 25 times more toxic, since the M.A.C. has been reduced from 25 ppm to five ppm. There was no gasoline automobile engine exhaust blow-by to accuse in the Idarado mine.

To continue the test previously mentioned, the exhaust of a 10 hp diesel engine was discharged into the same tank containing 14 liters of water, the same amount as was used in the 60-minute test on the gasoline engine exhaust. In nine minutes, the 14 liters of water was saturated to a pH of 2.5. It was demonstrated by the classic "Diphenylamine" method (Scott's Standard Methods of Analysis, 5th Edition, page

(*Continued on p. 493*)

New Ideas On Dust And Fume Control



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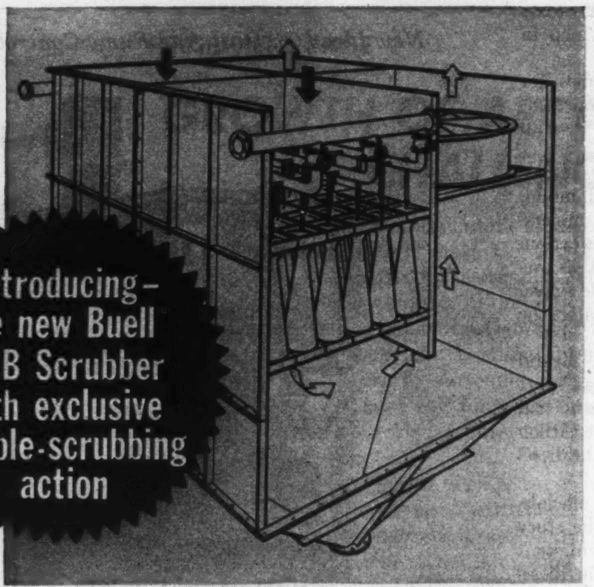

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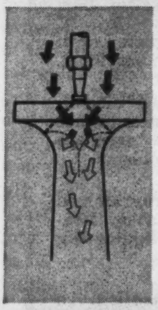

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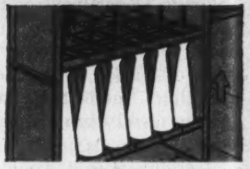

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A Monthly Journal
Devoted to
Air Purification

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A COMPARISON *of Observed Plume* RISES *with* VALUES *Obtained from Well-Known* FORMULAS[*,†]

HARRY MOSES, Associate Meteorologist, Radiological Physics Division, Argonne National Laboratory, Argonne, Illinois, and
GORDON H. STROM,[‡] Professor of Aeronautics, New York University, New York, New York

The height to which a stack effluent will rise in the atmosphere is of importance in calculating the resulting concentrations at ground level. There are at least eight theoretical or empirical formulas one may use,[1-11] but these yield results which may differ by as much as an order of magnitude. Up to the present time reliable measurements under varying stack and meteorological conditions, adequate to test these formulations, have been few. This paper compares the predictions of six such formulas with data obtained with an experimental stack operated by the Meteorology Group at the Argonne National Laboratory.[12] The formulas tested are those of: *(1)* Holland, *(2)* Davidson and Bryant, *(3)* Sutton, *(4)* Scorer, *(5)* Bosanquet, Carey, and Halton, and *(6)* an additional one by Bosanquet.

Equipment and Technique

Smoke plumes are obtained by injecting fog-oil droplets into the airstream supplied to the 111-foot Meteorology Experimental Stack by a 4500 cfm, $7^{1}/_{2}$ hp blower. The stack has an inside diameter of 17.5 inches and an outside diameter of 18 inches. Both flow rate and fog-oil concentration can be controlled by louvered dampers. A continuous record of the stack velocity is obtained by a Hagan Ring Balance pressure differential recorder which measures the pressure drop across an orifice plate in the stack.

The effluent air-smoke temperature is measured by two pencil-type copper constantan thermocouples inserted into the stack, one at 31 feet above the base, and the other $^{1}/_{2}$ foot from the top. Once each minute the temperature near the top of the stack is recorded for 40 seconds and that at 31 feet for 20 seconds, alternately, on a Minneapolis-Honeywell Electronik self-balancing potentiometer recorder.

Speed and Crown Graphic cameras using four-inch by five-inch film photograph the plume; one located 40 feet from the foot of the stack points vertically; the other 1000 feet from the plume photographs its side. The camera aimed vertically is equipped with a 12.7-cm f4.7 Kodak Ektar lens; the more distant camera has a 38-cm f5.6 Graflex Tele-Optar lens, both using Kodak Contrast Process film. Sixteen exposures per film (one every 15 seconds) are made to observe the plume for about four minutes.

The associated meteorological equipment used for this study has been described elsewhere.[13] Briefly, wind speed and direction are measured by Aerovanes, while temperature and stability are measured by aspirated copper constantan thermocouples. These instruments (except for the ones nearest the ground) are mounted at four logarithmically spaced levels on the 150-foot Meteorology Tower located 225 feet from the Meteorology Experimental Stack. The Esterline-Angus recorders for wind and Minneapolis-Honeywell

Table I—Meteorological and Stack Parameters

			Meteorological Parameters			Stack Parameters	
Run No.	Date, 1955	Beginning Time of Run, CST	Wind Speed, MPS	Lapse Rate, °C/100M	Air Temp, °K	Stack Effluent Vel., MPS	Effluent Temp, °K
15	8/4	$1806^{1}/_{2}$	3.94	+2.1	304.0	8.03	320.0
18	8/9	1750	1.00	+2.8	297.9	12.25	314.7
19	8/9	$1801^{1}/_{2}$	1.00	+3.6	298.2	10.53	316.3
20	8/9	1826	1.61	+4.7	297.6	12.53	311.9
26	8/10	1816	1.39	+0.5	298.2	6.49	326.9
27	8/10	1822	1.25	+0.5	298.2	4.83	320.8
28	8/10	$1835^{1}/_{2}$	1.39	+2.4	297.8	7.65	315.2
30	8/12	$0940^{1}/_{2}$	5.92	−1.2	297.6	12.65	309.7
33	8/12	$1001^{1}/_{2}$	4.47	−1.4	297.5	4.73	330.2
37	8/16	1751	0.98	+3.6	301.8	9.63	320.0
38	8/16	1818	1.12	+5.0	301.6	9.65	321.0
39	8/16	1824	1.12	+5.9	301.4	6.71	326.0
42	8/18	$1529^{1}/_{2}$	3.40	−0.9	304.7	12.68	319.7
45	8/18	$1622^{1}/_{2}$	2.19	+0.0	304.0	12.90	321.9
49	8/18	$1728^{1}/_{2}$	2.21	+1.7	303.4	8.15	330.0
51	8/18	$1806^{1}/_{2}$	2.26	+4.3	302.8	8.27	327.0
52	8/19	1031	1.98	−1.2	303.5	13.18	326.0
62	8/22	$1043^{1}/_{2}$	6.50	−1.4	299.7	10.33	323.0
99	9/7	$1053^{1}/_{2}$	5.50	−0.9	292.0	12.94	313.0
101	9/7	1103	7.02	−1.4	291.5	10.54	314.7
102	9/7	$1108^{1}/_{2}$	6.17	−1.7	291.4	7.70	319.7
103	9/7	1114	7.30	−1.4	291.5	7.70	319.7
104	9/7	$1119^{1}/_{2}$	6.17	−1.4	291.5	4.87	327.4
106	9/8	1525	6.35	−0.4	292.9	13.00	308.0
107	9/8	$1530^{1}/_{2}$	5.94	−0.4	292.8	10.78	310.0
108	9/8	$1536^{1}/_{2}$	5.50	−0.4	292.6	7.98	317.0
111	9/12	$0542^{1}/_{2}$	3.67	+12.3	280.1	13.00	297.4
112	9/12	0552	3.95	+11.9	281.0	12.94	295.2
113	9/12	0602	4.47	+13.00	281.4	12.97	295.8
115	9/12	$0655^{1}/_{2}$	3.42	+6.4	282.1	13.03	299.1
116	9/12	0706	2.83	+5.2	282.7	13.07	300.8
117	9/12	$0712^{1}/_{2}$	2.07	+3.6	283.2	13.08	301.3
118	9/12	0725	1.29	+0.5	282.2	13.16	304.1
119	9/13	$1259^{1}/_{2}$	5.59	−0.7	291.4	12.94	309.0
122	9/13	$1315^{1}/_{2}$	5.36	−0.5	291.8	12.83	308.0
123	9/13	1320	5.36	−0.5	291.9	12.83	308.0

---

[*] Presented at the 54th Annual Meeting of APCA, Commodore Hotel, June 11–15, 1961, New York, New York.

[†] Work performed under the auspices of the U. S. Atomic Energy Commission.

[‡] Resident Research Associate, Radiological Physics Division, Argonne National Laboratory, summers 1955–58 and 1960.

Electronik potentiometers for temperature are located in the Meteorology Building.

Analysis of the Data

From the photographs obtained by the two cameras, it is possible to obtain the position in space of the top and bottom of the plume to a maximum distance of about 300 feet downwind from the stack. The center line of the plume, located midway between the observed top and bottom positions, is compared with the predictions of the plume rise formulas. Samples of the data are presented graphically in Fig. 1.

Wind speed values used in this study are obtained by plotting five readings (from 79 inches to 150 feet) on log-log paper and interpolating the 120-foot wind speed. Values of stability are obtained by measurements of the temperature difference between 144 and 5.5 feet above ground.

Meteorological and stack parameters for each run are shown in Table I.

The Plume Rise Equations

The equations used to calculate the heights of rise according to each of the six techniques are presented in detail below. All of the theoretical formulas have shortcomings since simplifying assumptions were necessary in their derivation. Some of these are pointed out; however, a detailed critique of each of the formulations is beyond the scope of this paper.

The very interesting technique for calculating the height of rise of a bent-over plume given by Priestley[6] is not included because his equations are specific to a zero temperature gradient. Too few measurements in this study were made under this condition.

The Davidson-Bryant Technique

Using data obtained from Bryant's wind tunnel experiments,[15] Davidson derived the following empirical expression:[4]

$$\Delta h = d\left(\frac{V_s}{u}\right)^{1.4}\left(1+\frac{\Delta T}{T}\right) \quad (1)$$

where:

Δh = rise of the plume above the stack
d = inside stack diameter
V_s = stack velocity
u = wind speed
ΔT = temperature excess of effluent gas over ambient temperature (°K)
T_s = stack gas temperature (°K).

Any consistent system of units may be used.

This expression does not consider stability, and the calculated values are too low.[2] Nevertheless, it has been widely used, probably because it is simple to apply.

The Holland Technique

Holland[2] presented the following empirical expression for calculating the height above the stack, Δh, to which a plume will rise:

$$\Delta h = \frac{1.5\,V_s d + 4 \times 10^{-5} Q_H}{u} \quad (2)$$

where:

V_s = stack velocity in meters per second
d = inside stack diameter in meters
Q_H = heat emission rate in calories per second
u = horizontal wind speed in meters per second.

This formula is a modification of one presented by Rupp, Beall, Bornwasser, and Johnson,[3] based on wind tunnel tests and was used to predict the behavior of the Oak Ridge X-10 reactor cooling air exhaust. The formula by Rupp, et al., contained a momentum term only. By employing height of rise data from three stacks, two operated by Oak Ridge and a third by the Tennessee

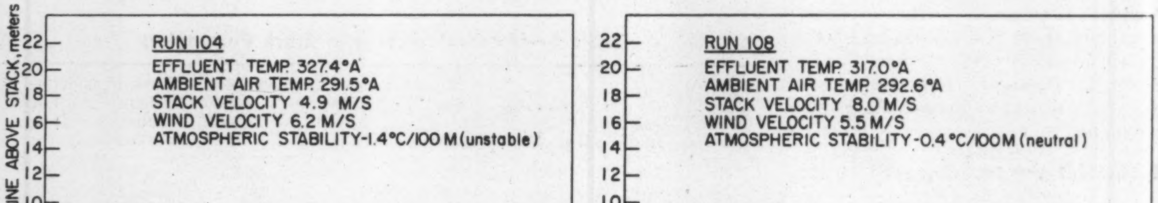

Fig. 1. Heights of plume rise.

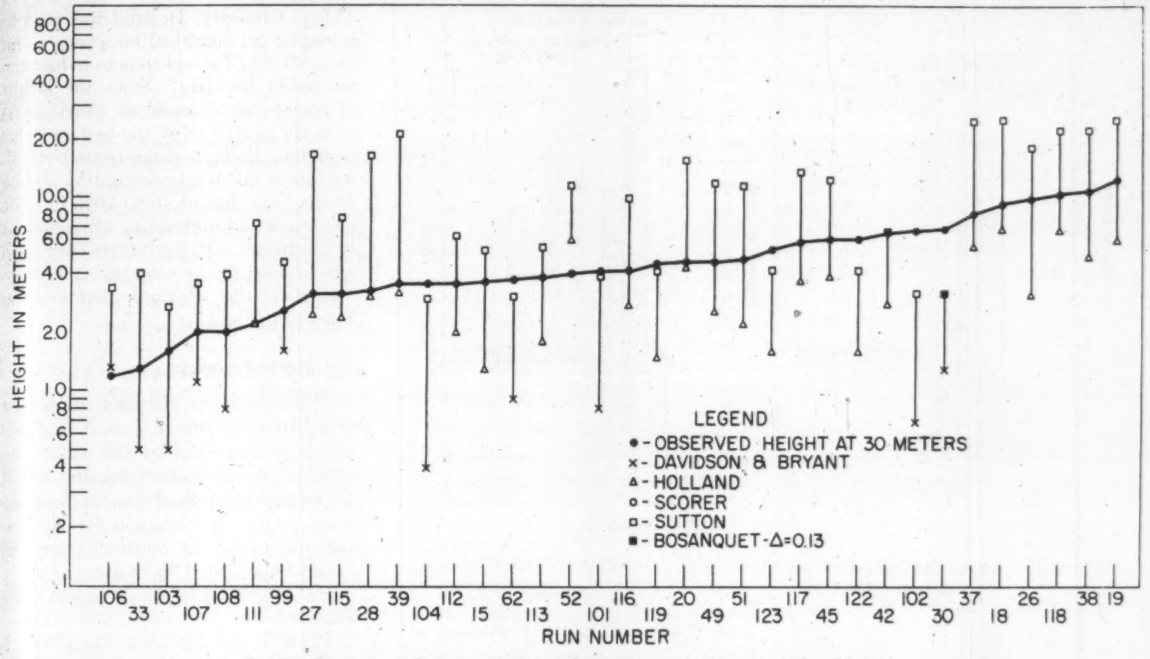

Fig. 2. Comparison of observed height with maximum and minimum calculated heights.

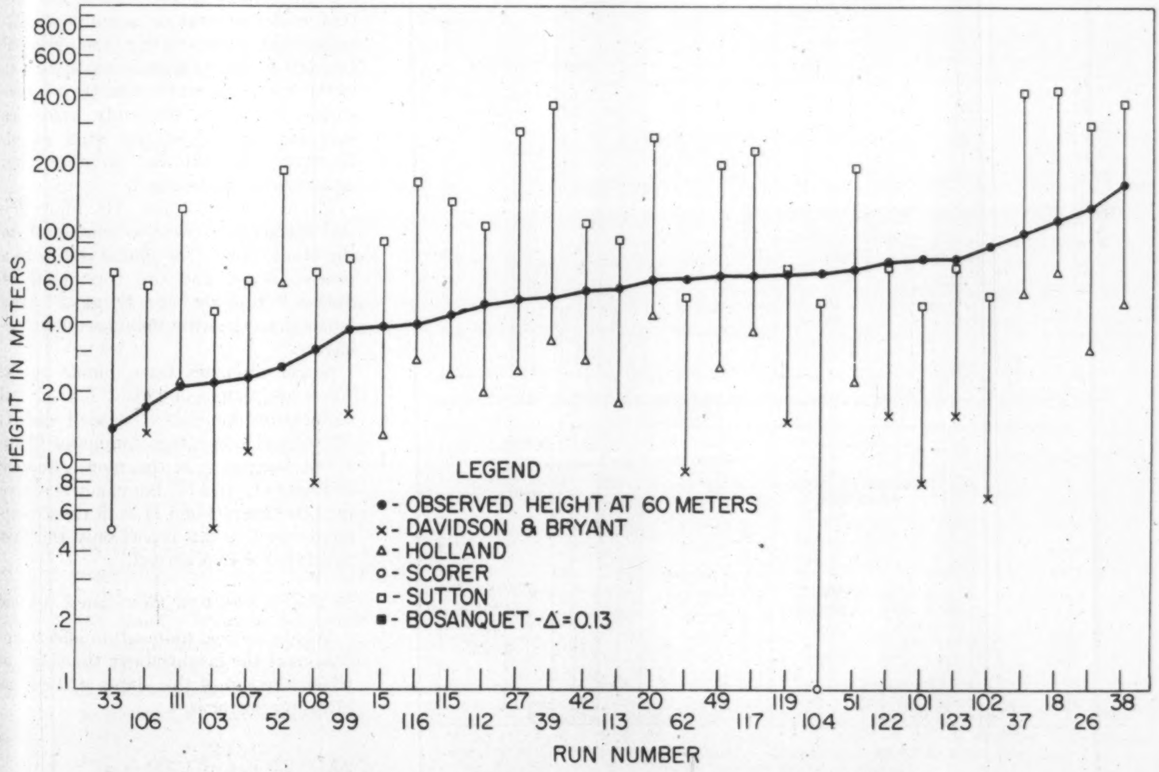

Fig. 3. Comparison of observed height with maximum and minimum calculated heights.

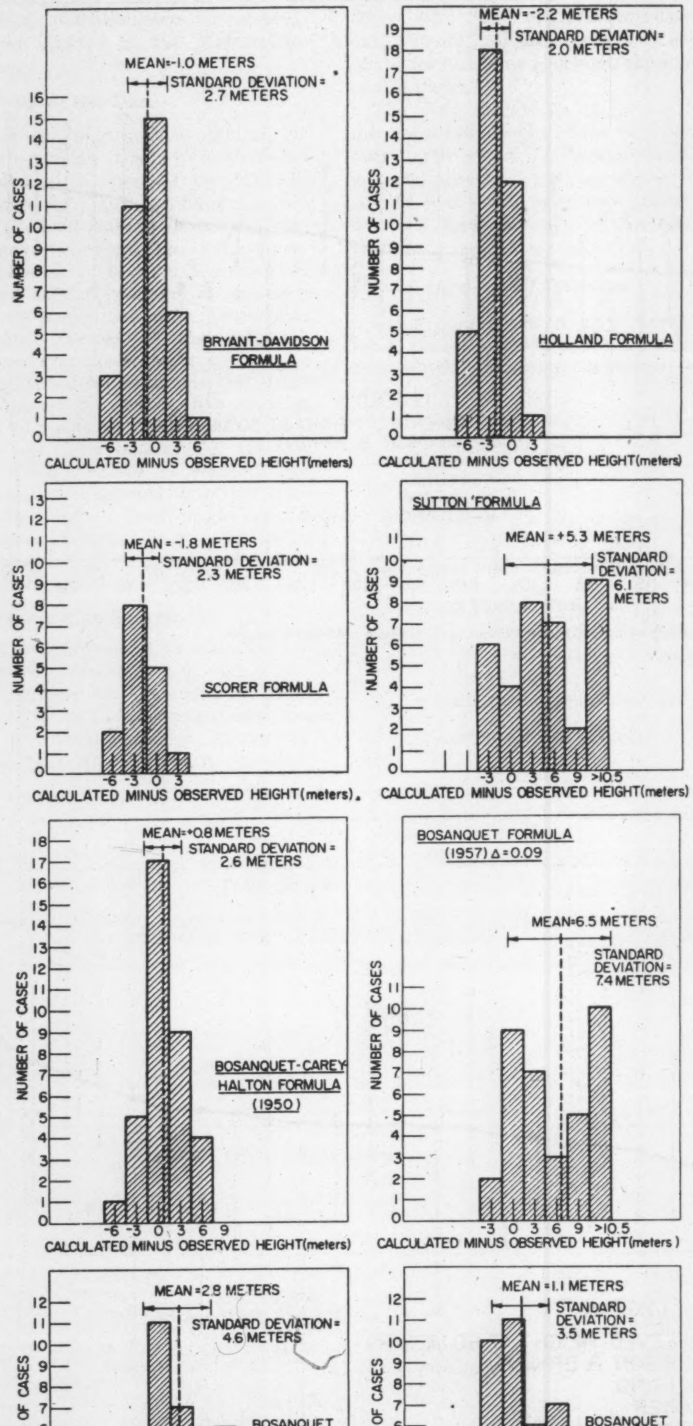

Fig. 4. Histogram of difference between observed and calculated height 30 meters.

Valley Authority, Holland was able to introduce an empirical buoyancy term, $(4 \times 10^{-5}Q_H)/u$, and thus to reduce the scatter in his data. Since the height of plume rise depends on atmospheric stability as well as on the factors in his equation, Holland suggests that stability can be taken into account by adding to the mean height 10 to 20% in lapse conditions and subtracting a like amount in inversions. This arbitrary correction was applied to the calculations used to construct the Holland diagrams in Figs. 4, 5, 6, and 7.

The Scorer Technique

This method is discussed in greater detail than the others since it has been extended somewhat by the authors to provide an equation giving the height of rise as a function of distance from the stack. Only the technique for calculating the height at which leveling off occurs is presented by Scorer.

He assigns three phases to the rising plume:

Phase I—In this phase the plume is nearly vertical and the upward velocity exceeds the horizontal wind velocity. Phase I ends and Phase II begins when the vertical velocity approximately equals the horizontal wind velocity.

Phase II—This is the transition stage in which the plume bends over and becomes horizontal. Phase II ends when the vertical velocity drops to a value equal to the turbulent velocities of the atmospheric eddies. Scorer assumes that under neutral or unstable conditions this occurs when the vertical velocity is approximately equal to $^1/_{10}$ of the horizontal wind velocity. Under stable conditions the eddy velocities may fall to $^1/_{100}$ of the wind speed. However, the formulas do not apply under stable conditions.[10]

Phase III—In Phase III buoyancy and momentum cease to contribute to the plume rise. The plume is now in a passive stage, and the treatments of Sutton,[16] Roberts,[17] or Frenkiel[18] may be used to describe its subsequent behavior.

Scorer discusses three plume types. These are plumes in which: (*1*) vertical momentum dominates Phases I and II; (*2*) vertical momentum dominates Phase I but buoyancy is the more effective in Phase II; and (*3*) buoyancy is active in both Phases I and II. In the experiments used in this report only the first two types were observed.

1 The momentum dominated plume

Where vertical momentum effects are dominant the height above the stack to which the top of the plume will rise as given by Scorer is

$$\Delta h = 2.5\, r_0 \left\{ \frac{V_s}{u}(\lambda^{-1/2} - \mu^{-1/2} + \right.$$

$$2\,\mu^{-1}) - 2\Big\} \qquad (3)$$

where:

r_0 = stack radius in meters
V_s = effluent exit velocity in meters per second
u = wind speed in meters per second
μ = a proportionality constant. The second phase begins when w, the vertical velocity of the effluent, is equal to μu. μ is assumed equal to 1
λ = a proportionality constant. The third phase begins when $w = \lambda u$, and λ is assumed equal to 0.1.

In extending Scorer's work to derive an expression giving plume height as a function of distance, use is made of his supposition that in a bent-over (horizontal) section of unit length, vertical momentum is conserved,[8] so we may write

$$wr^2 = w_1 r_1^2 = K = \text{constant, and consequently}$$

$$wy^2 = w_1 y_1^2 = K_1 = \text{constant} \qquad (4)$$

since $y = 2.25\ r$ as determined from laboratory measurements. The symbol r represents an effective plume radius, y is the height above a virtual origin associated with the bent-over portion of the plume, and the subscript 1 refers to the level at which the bend-over occurs.

Since $w = (dy/dt)$ where t is time, we have from equation (4) $y^2(dy/dt) = K_1$ and

$$\int_{y_1}^{y} y^2\,dy = K_1 \int_{t_1}^{t} dt$$

therefore

$$\frac{1}{3}(y^3 - y_1^3) = K_1\,(t - t_1) = \frac{K_1}{u}\,(x - x_1)$$

since $x = ut$, where x is the distance downwind, and u is assumed constant.

Solving for y

$$y = \left[\frac{3\,K_1}{u}\,(x - x_1) + y_1^3\right]^{1/3} \qquad (5)$$

In Phase I, because momentum is conserved, Scorer shows that

$$wz = V_s z_0 = K_2 = \text{constant} \qquad (6)$$

where z is the height above a virtual origin located in the stack and the subscript 0 refers to conditions at the top of the stack. It is to be noted that the origin from the bent-over position of the plume is different from the origin of the vertical jet.

Since $w = dz/dt$ we have from equation (6)

$$z\,\frac{dz}{dt} = K_2$$

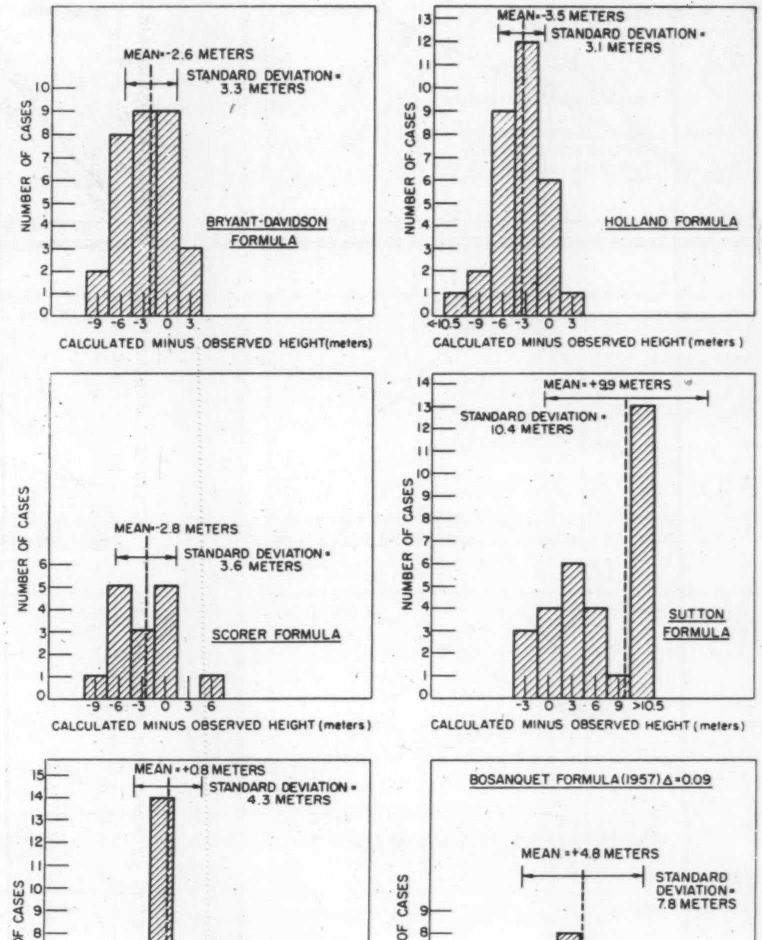

Fig. 5. Histogram of difference between observed and calculated height—60 meters.

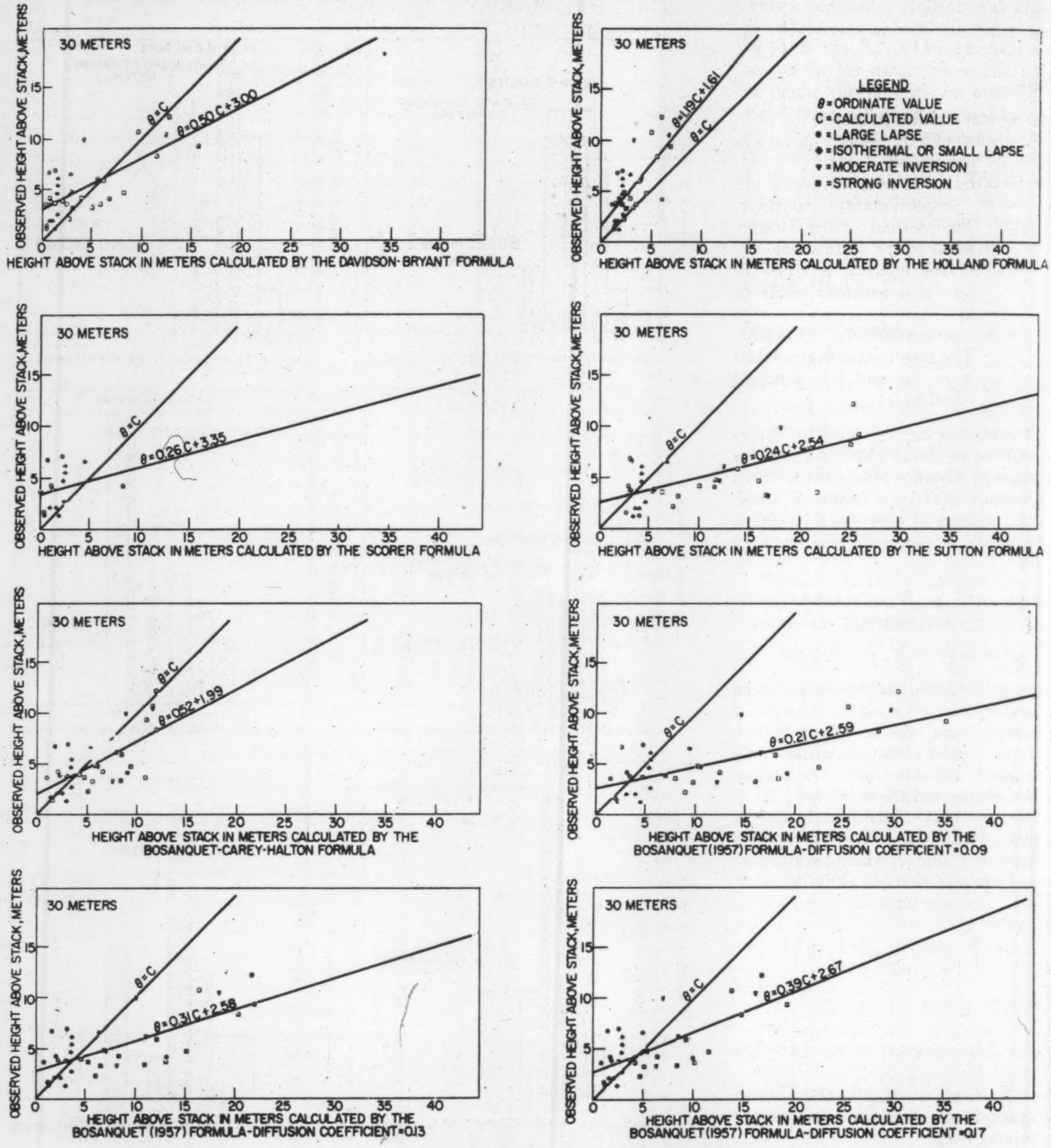

Fig. 6. Scatter diagram of observed vs calculated height—30 meters.

and

$$\int_{z_0}^{z} z\,dz = K_a \int_0 dt$$

$$\frac{1}{2}(z^2 - z_0^2) = K_2 t$$

and

$$z^2 = 2\,K_2 t + z_0^2$$

At the point of the bend-over

$$z_1^2 = 2\,K_2 t_1 + z_0^2$$

and since $x = ut$

$$z_1^2 = 2\,K_2\,\frac{x_1}{u} + z_0^2$$

But since $K_2 = w_1 z_1$ and $w_1 = \mu u$

$$z_1^2 = 2\,z_1\,\frac{\mu u\,x_1}{u} + z_0^2 = 2\,z_1 x_1 + z_0^2 \approx 2\,z_1 x_1$$

Therefore, we assume

$$z_1 = 2\,x_1$$

Substituting for x_1, in equation (5), we have

$$y = \left[\frac{3\,K_1}{u}\left(x - \frac{z_1}{2}\right) + y_1^3\right]^{1/3}$$

Scorer shows that $z_1 = (5\,r_0 \bar{V}_s)/u$, and $y_1 = (2.5\,r_0 V_s)/u$ and since $K_1 = w_1 y_1^2 = \mu u y_1^2 \approx u y_1^2$ we have

$$y = \left\{\frac{r_0^2 V_s^2}{u^2}\left[18.75\,x - 31.25\,\frac{r_0 V_s}{u}\right]\right\}^{1/3}$$

Since y refers to the cap of the plume, it is necessary to calculate the height of the center line for comparison with our

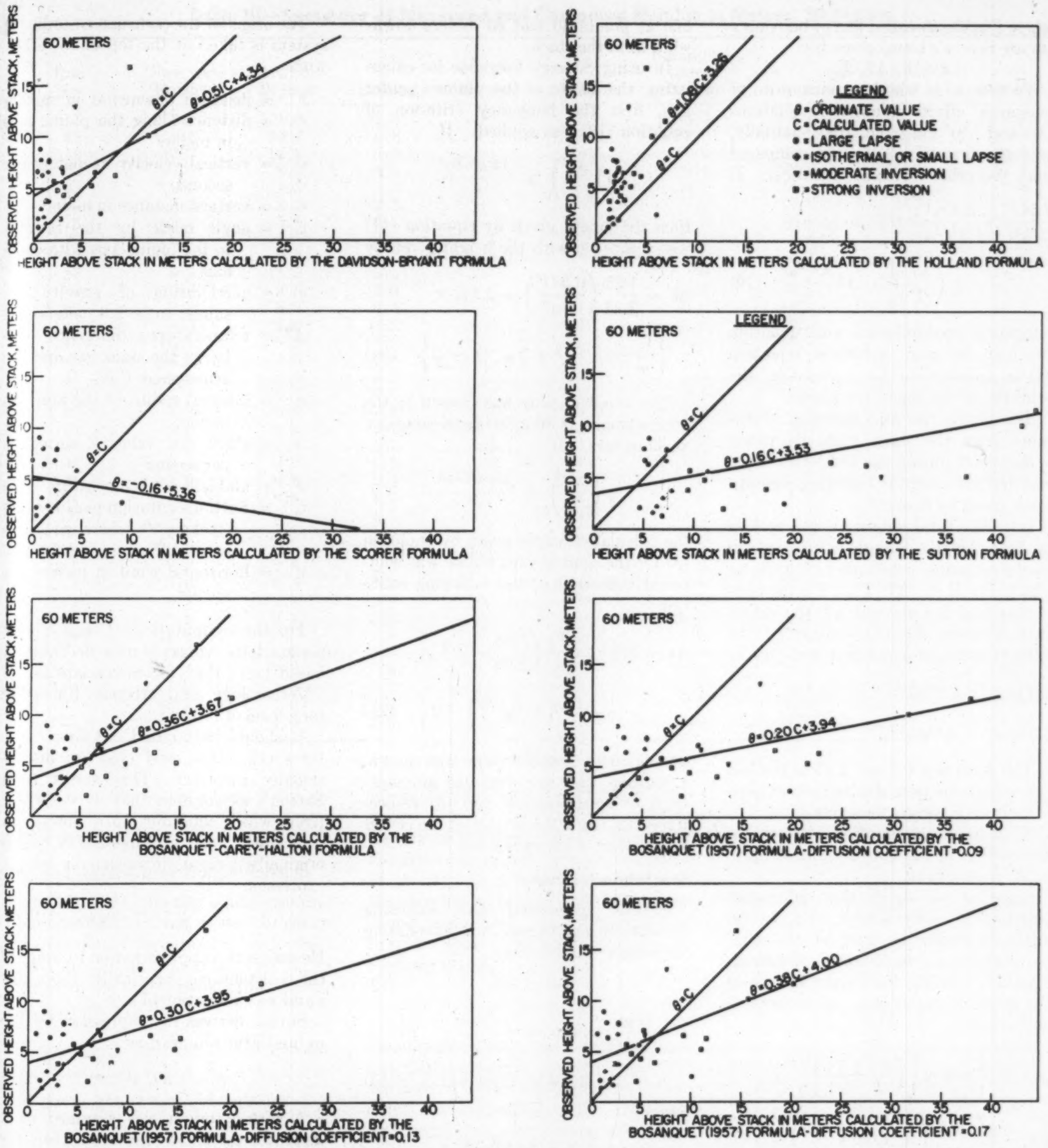

Fig. 7. Scatter diagram of observed vs calculated height—60 meters.

measurements.

Under the assumption that $y = 2.25\,r$, the height of the center line above the virtual origin (h_{cl}) for the bent-over plume is therefore

$$h_{cl} = y - r = y - \frac{y}{2.25} = 0.555\,y$$

$$h_{cl} = 0.555\left\{\frac{r_0^2 V_s^2}{u^2} \times \left(18.75\,x - 31.25\,\frac{r_0 V_s}{u}\right)\right\}^{1/3} \quad (7)$$

To obtain the height of the center line above the virtual origin in the stack (${}_sh_{cl}$), we must calculate the height of rise before bend-over, $z_1 - z_0$, and the height during bend-over, $h_{cl} - y_1$. Therefore, the equation for the center line of the plume as a function of distance from the stack is given by

$${}_sh_{cl} = (h_{cl} - y_1) + (z_1 - z_0)$$

$$= \left\{\frac{r_0^2 V_s^2}{u^2}\left(3.22\,x - 5.34\,\frac{r_0 V_s}{u}\right)\right\}^{1/3} + \frac{2.5\,r_0 V_s}{u} - 5\,r_0 \quad (8)$$

This equation was used to calculate the heights of the nonbuoyant plume center line at 30 and 60 meters.

2 The plume with buoyancy active in Phase II

When buoyant effects dominate the bend-over phase the height of rise (h) is given by

$$\Delta h = \frac{0.58\,F}{\lambda^2 u^3} + 2.5\,r_0 \times \left\{\frac{V_s}{u}\left(-\mu^{-1/2} + 2\,\mu^{-1}\right) - 2\right\} \quad (9)$$

where F is the so-called flux of buoyancy (to use Scorer's term) given by

$$g\,\pi\,r_0{}^2 V_s(\Delta T/T)_0.$$

To determine whether momentum or buoyancy effects dominate, equations (3) and (9) are compared—actually, only the first terms need be compared since the other terms are identical. If

$$\frac{0.58\,F}{\lambda^2 u^3} > \frac{2.5\,r_0 V_s}{\lambda^{1/2} u} \text{ or more simply}$$

$$g\left(\frac{\Delta T}{T}\right)_0 > .14\,\frac{\lambda^{3/2}u^2}{r_0} \quad (10)$$

buoyancy predominates and equation (9) may be used, otherwise equation (3) is appropriate for calculating the total rise of the top of the plume.

The plume rise as a function of distance from the stack when buoyancy is dominant during the bend-over stage was derived using the following assumptions given by Scorer:[9]

(1) The total buoyancy in a section of unit length bounded by vertical planes remains constant, i.e., $y_1{}^2B_1 = y^2B$ where $B = (\Delta T/T)$. T is the temperature of the air and ΔT the difference between the temperature of the effluent at height y and that of the air.

(2) $r = y/2.25$.

(3) $w = 0.8(gBr)^{1/2}$.

The constants 0.8 and 2.25 in the last two equations were determined empirically from laboratory models.

With these assumptions it can be shown that in the buoyant plume $wy^{1/2} = K =$ constant.

Since $w = dy/dt$ the differential equation is easily solved, and, by an analysis similar to that of the nonbuoyant plume, we obtain the following equation relating the height of rise of the plume's center line as a function of distance:

$$_Bh_{cl} = \left\{2.58\,r_0\left[\left(\frac{\Delta T}{T}\right)\frac{V_s}{u^3}\right]^{1/2} \times \left(x - 2.5\,\frac{V_s r_0}{u}\right) + 1.62\left(\frac{V_s r_0}{u}\right)^{3/2}\right\}^{2/3} + 2.5\,\frac{V_s r_0}{u} - 5\,r_0 \quad (11)$$

This equation was used to calculate the rise of the buoyant plume center line at points 30 and 60 meters downwind from the stack.

In using Scorer's formulae for calculating the height of the plume's center line, first the buoyancy criterion of equation (10) was applied. If

$$g\left(\frac{\Delta T}{T}\right)_0 > \frac{.14\,\lambda^{3/2}u^2}{r_0}$$

then the height given by equation (11) was compared with the height given by

$$\Delta h = \frac{1.25}{2.25}\left(\frac{0.58\,F}{\lambda^2 u^3}\right) + 2.5\,r_0 \times \left\{\frac{V_s}{u}\,(-\mu^{-1/2} + 2\,\mu^{-1}) - 2\right\} \quad (9a)$$

The smaller value was chosen as the plume height at 30 meters and similarly at 60 meters. If

$$g\left(\frac{\Delta T}{T}\right)_0 < \frac{.14\,\lambda^{3/2}u^2}{r_0}$$

the calculated height given by equation (8) for the nonbuoyant plume was compared with that of the following equation:

$$\Delta h = 2.5\,r_0\left\{\frac{V_s}{u}\left(\frac{1.25}{2.25}\lambda^{-1/2} \times - \mu^{-1/2} + 2\mu^{-1}\right) - 2\right\} \quad (3a)$$

and again the smaller value was chosen. Equations (3a) and (9a) are modifications of equations (3) and (9) respectively, and give the heights of the center line instead of the plume top.

The Sutton Technique

Sutton[1] presented the following theoretical expressions for calculating the height of plume rise:

$$w_1{}^3 = w^3 s \quad (12)$$

$$z = \frac{3}{2}\,\frac{w_1{}^3}{u^3}\,[\cot\psi\csc\psi - \ln(\cot\psi + \csc\psi)] \quad (13)$$

where

$$w_1{}^3 = \frac{7}{3}\left\{\frac{g\Delta T r^2_0 V_s}{TC}\right\} \quad (14)$$

from which it follows that

$$x = \frac{w_1{}^3}{u^3}\left[\frac{\cot^2\psi - 2}{\sin\psi} + 2\right] \quad (15)$$

Table II—Selected Sutton Parameters

	Stability	C(meters)$^{n/2}$	n
Large lapse	$\frac{\partial T}{\partial z} \le -1°\text{C}/100$ meters	0.20	0.20
Isothermal or small lapse	$0 \ge \frac{\partial T}{\partial z} > -1°\text{C}/100$ meters	0.11	0.25
Moderate inversion	$0 < \frac{\partial T}{\partial z} < 2°\text{C}/100$ meters	0.07	0.33
Strong inversion	$\frac{\partial T}{\partial z} \ge 2°\text{C}/100$ meters	0.06	0.50

The origin of the cartesian co-ordinate system is taken at the top of the stack with:

x = distance downwind in meters
s = distance along the plume axis in meters
w = vertical velocity in meters per second
z = vertical distance in meters
ψ = angle made by the tangent to the plume axis with the x axis
g = acceleration of gravity assumed to be 9.8 meters/sec^2
ΔT = temperature difference between the stack gas and the atmosphere (°K)
r_0 = internal radius of the stack in meters
V_s = stack exit velocity in meters per second
T = ambient air temperature (°K)
C = Sutton's diffusion parameter in (meters)$^{n/2}$ where n is another diffusion parameter
u = horizontal wind in meters per second.

For the computations, C and n were assigned the values shown in Table II based on the recommendations of "Meteorology and Atomic Energy"[14] for a level of 110 feet.

It should be pointed out that equations (12), (13), and (15) are dimensionally incorrect. This stems from Sutton's assumption that $w = w_1 s^{-1/3}$ (from which equation (12) follows) is a sufficiently good approximation to his originally derived, dimensionally correct expression

$$w = w_1 s^{-(2-n)/6}$$

He makes this approximation to simplify the calculations, especially those for z and x as a function of ψ.

Sutton derives the expression for the radius of the plume, r, as:

$$r = 1.5\,C\,z^{(2-n)/2} \quad (16)$$

A virtual origin was assumed at a distance, z_0, below the stack top for which r equaled r_0, the stack radius. The distance of the virtual origin below the stack top (z_0) was calculated from the equation

$$z_0 = \left(\frac{r_0}{1.5\,C}\right)^{2/(2-n)} \quad (17)$$

If the theoretical plume were plotted from the virtual origin, the plume axis would cross the level corresponding to the stack top, the zero level, a distance downwind from the stack. This, of course, was unreal. The entire theoretical plume was translated upwind so that it crossed the top of the stack. This correction still presents inherent difficulties since its inclination at the stack top differs from the virtual in-

Table III—Summary of Measured and Computed Heights in Meters, 30 Meters

Run No.	Observed Height	Davidson-Bryant	Holland	Scorer	Sutton	Bosanquet-Carey-Halton	Bosanquet, 1957		
							Δ = 0.09	Δ = 0.13	Δ = 0.17
15	3.7	1.3	1.3	—	5.3	3.0	4.6	3.1	2.4
18	9.3	15.7	6.8	—	25.9	11.0	34.9	22.0	19.3
19	12.2	12.7	5.9	—	25.3	11.9	30.1	21.7	16.7
20	4.7	8.2	4.4	—	15.9	9.4	22.2	15.2	11.4
26	9.9	4.2	3.1	—	18.1	8.9	14.4	10.1	6.8
27	3.2	3.2	2.5	—	16.9	7.6	12.0	8.2	6.2
28	3.3	5.1	3.1	—	16.7	8.4	15.9	11.0	8.3
30	6.9	1.3	2.0	2.2	3.0	3.1	4.6	3.2	2.4
33	1.3	0.5	1.2	0.5	4.0	1.6	2.1	1.4	1.1
37	8.3	11.5	5.5	—	25.1	12.0	28.2	20.4	14.7
38	10.7	9.6	4.9	—	22.7	11.6	25.1	16.4	13.7
39	3.6	5.9	3.4	—	21.8	10.9	18.2	13.1	10.0
42	6.5	2.9	2.8	4.6	6.7	5.4	9.3	6.4	4.8
45	6.1	5.6	3.9	—	12.4	8.0	16.4	11.1	8.4
49	4.7	3.0	2.6	—	12.0	6.1	10.4	7.1	5.3
51	4.8	2.9	2.2	—	11.6	5.9	10.1	6.9	5.2
52	4.1	6.8	6.0	8.4	11.5	9.1	19.1	13.2	9.9
62	3.8	0.9	1.8	1.3	3.1	2.3	3.3	2.3	1.7
99	2.6	1.6	2.1	2.5	4.6	3.5	5.4	3.7	2.8
101	4.2	0.8	1.7	1.2	2.9	2.1	3.0	2.1	1.6
102	6.7	0.7	1.5	0.8	3.2	1.8	2.5	1.7	1.3
103	1.6	0.5	1.3	0.5	2.7	1.4	1.9	1.3	1.0
104	3.6	0.4	1.0	0.1	3.0	1.0	1.4	0.9	0.7
106	1.2	1.3	1.7	2.0	3.4	3.0	4.4	3.1	2.3
107	2.0	1.1	1.6	1.7	3.6	2.6	3.9	2.6	2.0
108	2.0	0.8	1.3	1.1	4.0	2.1	3.0	2.0	1.5
111	2.2	2.8	2.2	—	7.4	5.2	8.9	6.1	4.6
112	3.6	2.5	2.0	—	6.3	4.8	7.9	5.4	4.1
113	3.9	2.1	1.8	—	5.5	4.3	6.9	4.7	3.6
115	3.2	3.1	2.4	—	7.9	5.6	9.7	6.6	5.0
116	4.2	4.0	2.8	—	10.0	6.6	12.3	8.4	6.3
117	5.9	6.2	3.7	—	13.8	8.5	17.9	12.2	9.2
118	10.4	12.3	6.6	—	22.6	11.6	29.4	18.4	16.1
119	4.6	1.5	2.0	2.4	4.2	3.4	5.2	3.6	2.7
122	6.1	1.6	2.0	2.6	4.2	3.5	5.4	3.7	2.8
123	5.4	1.6	2.0	2.6	4.2	3.5	5.4	3.7	2.8

clination of the actual plume. Nevertheless, this correction provides a better fit for the data.

The Bosanquet-Carey-Halton Formula

In this technique the plume rise due to momentum and that due to buoyancy are computed separately and then added to obtain the total rise. The maximum rise due to momentum effects, $z_{\max}$, is given by

$$z_{\max} = \frac{4.77}{1 + 0.43\, u/V_s} \frac{\sqrt{QV_s}}{u} \quad (18)$$

and the height at any distance by

$$hv = z_{\max}\left(1 - 0.8\,\frac{z_{\max}}{x}\right) \quad (19)$$

where $x >$ about $2\, z_{\max}$ and where Q is the volumetric emission rate, x is the distance downwind, V_s the stack velocity. Any consistent system of units may be used.

The rise due to buoyancy h_B at a distance x may be obtained from the equations

$$x = 3.57\,\frac{\sqrt{QV_s}}{u}\,X \quad (20)$$

and $h_B = \dfrac{6.37\, gQ(T_g - T_1)}{\mu^3\, T_1}\, Z$

if $$u^2 > \frac{(T_g - T_1)g}{T_1}\sqrt{\frac{Q}{V_s}} \quad (21)$$

where T_g is the temperature of the stack gases, T_1 the temperature at which the density of the flue gases equals that of the atmosphere, and g is the acceleration of gravity. A graph showing the functional relation between the nondimensional parameters X and Z is presented in reference 5. The total rise above the chimney top (h_T) is given as

$$h_T = h_V + h_B \quad (22)$$

Bosanquet, Carey, and Halton point out that equations (19) through (22) are derived for an adiabatic atmosphere only, but suggest that the equations may be used close to the stack "without serious error" in a nonadiabatic atmosphere.

The Bosanquet (1957) Formula

Bosanquet[7] published another technique for calculating the height of rise of a smoke plume which follows the same general lines as that of his earlier paper[5] with Carey and Halton. Bosanquet claims to have simplified the computation.

In comparing the Argonne experimental data with the 1957 Bosanquet technique, the following formula was used:

$$\Delta h = AU\left\{ f_{\mathrm{I}}(X) + f_{\mathrm{II}}(X_0) - \frac{0.615\, X_0^{1/2}}{[(V_s/U)^2 + 0.57]^{1/2}} \right\} \quad (23)$$

where

$$A = \frac{gQ\theta}{2\,\pi\Delta^2 T_1 U^4}$$

$$X = \frac{t + t_0}{A} = \frac{L}{UA} + \frac{t_0}{A}$$

$$t_0 = \frac{4}{3}\,\frac{V_s T_1}{g\theta}$$

$$X_0 = \frac{t_0}{A}$$

Tables for $f_{\mathrm{I}}(X)$ and $f_{\mathrm{II}}(X_0)$ are given in Bosanquet's paper. The other symbols have the following meaning: g is the acceleration of gravity; Q is the volumetric flow rate; θ is the temperature excess of the effluent over the temperature at which it would have the same density as that of the atmosphere; T_1 is the absolute temperature of the effluent at which it has the same density as that of the atmosphere. (In this study it is sufficiently accurate to assume T_1 = air temperature +8° since the variations in effluent density were small.) U is wind speed; Δ is a dilution coefficient; t is time in seconds; and L is distance from the stack. Any self consistent system of units may be used. Bosanquet assumed a value of

Table IV—Summary of Measured and Computed Heights in Meters, 60 Meters

Run No.	Observed Height	Davidson-Bryant	Holland	Scorer	Sutton	Bosanquet-Carey-Halton	Bosanquet, 1957		
							Δ = 0.09	Δ = 0.13	Δ = 0.17
15	3.9	1.3	1.3	—	9.3	3.2	4.6	3.1	2.4
18	11.7	15.7	6.8	—	43.9	20.2	37.6	23.3	20.2
20	6.3	8.2	4.4	—	27.0	12.5	22.5	15.3	11.5
26	13.1	4.2	3.1	—	30.5	11.6	16.6	11.2	7.5
27	5.2	3.2	2.5	—	28.5	9.6	13.5	9.0	6.7
33	1.4	0.5	1.2	0.5	6.7	1.6	2.2	1.5	1.1
37	10.2	11.5	5.5	—	42.5	18.7	31.4	21.9	15.7
38	16.9	9.6	4.9	—	38.4	16.6	27.5	17.7	14.4
39	5.3	5.9	3.4	—	37.0	14.7	21.4	14.7	11.0
42	5.7	2.9	2.8	4.6	11.2	6.1	9.3	6.4	4.8
49	6.6	3.0	2.6	—	20.3	7.2	10.8	7.3	5.4
51	7.1	2.9	2.2	—	19.9	6.9	10.5	7.1	5.3
52	2.6	6.8	6.0	9.1	18.9	11.6	19.7	13.5	10.1
62	6.4	0.9	1.8	1.3	5.3	2.4	3.3	2.3	1.7
99	3.8	1.6	2.1	2.5	7.7	3.7	5.4	3.7	2.8
101	7.9	0.8	1.7	1.2	4.9	2.2	3.1	2.1	1.6
102	9.0	0.7	1.5	0.8	5.4	1.8	2.5	1.7	1.3
103	2.2	0.5	1.3	0.5	4.5	1.5	1.9	1.3	1.0
104	6.8	0.4	1.0	0.1	5.0	1.1	1.4	0.9	0.7
106	1.7	1.3	1.7	2.0	5.8	3.1	4.4	3.1	2.3
107	2.3	1.1	1.6	1.7	6.2	2.8	3.9	2.7	2.0
108	3.1	0.8	1.3	1.1	6.8	2.2	3.0	2.0	1.5
111	2.1	2.8	2.2	—	12.8	5.8	8.9	6.1	4.6
112	4.9	2.5	2.0	—	10.9	5.3	7.9	5.4	4.1
113	5.8	2.1	1.8	—	9.5	4.6	6.9	4.7	3.6
115	4.4	3.1	2.4	—	13.7	6.3	9.7	6.6	5.0
116	4.0	4.0	2.8	—	17.1	7.7	12.4	8.4	6.4
117	6.6	6.2	3.7	—	23.5	10.6	18.2	12.3	9.3
119	6.7	1.5	2.0	2.4	7.1	3.6	5.2	3.6	2.7
122	7.7	1.6	2.0	2.6	7.2	3.8	5.4	3.7	2.8
123	7.9	1.6	2.0	2.6	7.2	3.8	5.4	3.7	2.8

0.13 for Δ. The inflow per unit area of the plume is the product of Δ and the wind speed. For a plume oriented longitudinally to the wind having a half-angle of 12° he shows that the inflow per unit area is 0.106 U. For a plume oriented transversely to the wind he shows that the inflow is 0.159 U. A value for Δ of 0.13 representing a compromise between 0.159 and 0.106 is therefore suggested by Bosanquet. In this study calculations were carried out for the values of Δ equal to 0.09, 0.13, and 0.17.

Discussion of Results

Since the plumes were photographed over a maximum length of only about 100 meters, one could not be certain of the final maximum height obtained. However, since the buoyancy of these plumes was relatively small (Table I), it appears that most of the rise had already occurred by the time the plumes reached the second check point 60 meters from the stack. In support of this assertion is the fact that the average slope of the center line between 30 and 60 meters was less than 5° in 27 of the 31 plumes measured to 60 meters. Four of these even showed a slight negative slope probably because of atmospheric downdrafts.

In this study the observed heights at both 30 and 60 meters are compared with either the maximum heights as given by the Davidson-Bryant and Holland equations, or the height at 30 and 60 meters as given by the other formulations. Tables III and IV summarize the measured and computed heights. Blanks occur in the Scorer columns because in accordance with his suggestions calculations for stable conditions were omitted. It is of interest to note that all Scorer calculations for 60 meters and all but one for 30 meters represent the plume as being in the passive stage—Phase III, further support for the observations of the previous paragraph.

Table V—Percent of Calculated Values within Indicated Height of Measured Values

Author	At 30 Meters		At 60 Meters	
	±1.5 Meters	±4.5 Meters	±1.5 Meters	±4.5 Meters
Davidson-Bryant	42	89	29	84
Holland	33	86	19	61
Scorer	31	87	33	60
Sutton	11	50	13	42
Bosanquet-Carey-Halton	47	86	45	74
Bosanquet (1957)				
Δ = 0.09	25	50	19	55
Δ = 0.13	31	64	42	71
Δ = 0.17	31	75	32	61

Comparison of Observed Values with Range of Calculated Values

In Figs. 2 and 3 the observed heights are arranged in increasing order and compared with the highest and lowest calculated values. At 30 meters 75%, and at 60 meters 74% of the measured heights fall within the range of calculated values. The Sutton values represent the maxima in all cases except one, while the minimum values are divided between the Davidson-Bryant, Holland, Scorer, and Bosanquet computations. In all probability atmospheric eddies with a time scale exceeding four minutes are responsible for the measured heights falling outside of the computed range.

Comparison by Histograms

Histograms showing the frequency distribution of the differences between calculated and observed values are shown in Figs. 4 and 5. The mean difference is shown by the dashed line and the standard deviation of the difference about the mean is indicated by arrows. From the position of the dashed mean difference line with respect to the zero line, one can tell at a glance whether the calculated values generally tend to be too low or too high. At 30 meters, the Davidson-Bryant and the Holland values were somewhat low and the others (not counting Scorer) were too high. At 60 meters the Bosanquet 1957 formula with a diffusion coefficient of 0.17 as well as those of Davidson-Bryant and Holland read somewhat low.

Holland[2] also found the Davidson-Bryant values too low when applied to his data.

Information on how frequently large errors occur or how often the formula predicts the height within some specified range may also be determined from these diagrams. The data of Table V showing for each technique the percent of calculated values falling within 1.5 and within 4.5 meters of the observed values are based on the histograms. It is of interest to note that the Davidson-Bryant formula predicted the height to within 4.5 meters in well over 80% of the runs. This was true of three of the other techniques for the 30-meter distance, but of only the Davidson-Bryant technique at 60 meters. The Sutton values were the least satisfactory.

Comparison by Scatter Diagrams

The observed and calculated plume rises are further compared in the scatter diagrams drawn for each of the formulas based on the measurements taken at 30 and 60 meters (Figs. 6 through 7). The four categories of stability used in this paper are denoted by a separate symbol as indicated in the legend of these figures. Also shown is a line through the origin of each graph inclined 45° to the horizontal. The scatter of points about this line is a measure of the validity of each formula since, if a particular expression were perfect, all of the points would lie along the line. The root mean square of the deviations about this line is shown in Tables VI and VII which summarize the results of this study. The reader should remember that when points lie above this line the calculated values are too low; when the points lie below the line the formula values are too high.

Also appearing on each scatter diagram is the least squares regression line with the formula value as the independent variable. Because the scatter of points about this line is smaller than that about any other line, it may be used as a practical tool to improve the accuracy of the calculated plume rises. The degree of improvement may be observed by comparing the standard error of estimate values (root mean square of the deviations about the regression line) with the values of the root mean square of the deviations about the 45° line (Tables VI and VII).

Calculation of the correlation coefficients as well as inspection of the data in the scatter diagrams disclose that the correlation between calculated and observed values appears better during stable conditions than during neutral or unstable conditions. This is rather severe on the Scorer technique since, in accordance with his suggestion,[10] only values for neutral and unstable conditions were included. Not only his, but all of the other techniques correlated poorly under these conditions. The graphs show that there is a considerable scatter of points and that the scatter at 60 meters exceeds that at 30 meters. The scatter of all of the points is due in part, no doubt, to the brevity of the four-minute observing period. Evidence for this is the varia-

Table VI—Statistical Summary of Calculated and Observed Plume Heights, 30 Meters

Parameter Units Are in Meters	Observed Height	Davidson-Bryant	Holland	Scorer	Sutton	Bosanquet-Carey-Halton	Bosanquet, 1957		
							$\Delta =$ 0.09	$\Delta =$ 0.13	$\Delta =$ 0.17
Mean height	5.0	4.1	2.9	2.1	10.3	5.9	11.5	7.9	6.1
Standard deviation	2.8	4.0	1.6	2.0	7.7	3.5	9.2	6.2	5.0
Calculated minus observed values									
Average difference		−1.0	−2.2	−1.8	5.3	0.8	6.5	2.8	1.1
Maximum difference		6.3	6.8	5.9	18.2	7.3	25.6	12.6	10.0
Correlation coefficient (calculated vs observed values)		0.71	0.69	0.26	0.66	0.64	0.69	0.69	0.69
Standard deviation of differences between calculated and observed values		2.7	2.0	2.4	6.1	2.7	7.5	4.7	3.6
Root mean square of differences (root mean square deviation of observed heights about 45° line in Fig. 6)		2.9	2.9	2.9	8.0	2.7	9.8	5.4	3.7
Standard error of estimate (root mean square deviation of observed heights about regression line)		1.9	2.0	1.9	2.1	2.1	2.0	2.0	2.0

Number of runs used for Scorer = 16; observed mean heights for Scorer = 3.9; standard deviation of observed values = 2.0; number of runs used for all other calculations = 36.

Table VII—Statistical Summary of Calculated and Observed Plume Heights, 60 Meters

Parameter Units Are in Meters	Observed Height	Davidson-Bryant	Holland	Scorer	Sutton	Bosanquet-Carey-Halton	Bosanquet, 1957		
							$\Delta =$ 0.09	$\Delta =$ 0.13	$\Delta =$ 0.17
Mean height	6.1	3.5	2.6	2.2	16.0	6.9	10.9	7.3	5.6
Standard deviation	3.5	3.6	1.5	2.2	12.2	5.3	9.3	6.1	4.8
Calculated minus observed values									
Average difference		−2.6	−3.5	−2.8	9.8	0.7	4.7	1.2	−0.6
Maximum difference		8.9	12.0	8.2	32.3	9.4	25.9	11.7	8.5
Correlation coefficient (calculated vs observed values)		0.52	0.46	−0.13	0.57	0.54	0.54	0.52	0.53
Standard deviation of differences between calculated and observed values		3.4	3.1	3.7	10.5	4.4	7.9	5.2	4.1
Root mean square of differences (root mean square deviation of observed heights about 45° line in Figs. 7a to 7h)		4.2	4.7	4.5	14.3	4.4	9.1	5.2	4.1
Standard error of estimate (root mean square deviation of observed heights about regression line)		2.9	3.1	2.6	2.8	2.9	2.9	2.9	2.9

Number of runs used for Scorer = 15; observed mean heights for Scorer = 5.0; standard deviation of observed values = 2.7; number of runs used for all other calculations = 31.

tion in observed plume height in consecutive runs only a few minutes apart. Eddies with time scales greater than four minutes would influence the plume height more than some of the variables that appear in the formulas. The increased scatter at 60 meters is probably the result of the longer time in which the eddies had a chance to act.

Conclusions

From the information contained in Tables V through VII, summarizing the results of this study, a suitable formula for calculating the height of plume rise may be selected. There is no one formula which is outstanding in all respects. The nature of the problem would influence the selection of the formula. For example, if there were interest in keeping to a minimum the average difference between the calculated and observed heights, one would select the formulas of Bosanquet-Carey-Halton or the Bosanquet (1957) with $\Delta = 0.17$. If a minimum root mean square difference between calculated and observed values were the desired condition, then one would choose the formulae of Bosanquet-Carey-Halton, Davidson-Bryant, or Holland. As a matter of practical consideration, the computation time is least for the Bryant-Davidson or Holland formulae.

Scorer's technique appears to be as valid as any of the others when compared with all of the data, i.e., including the stable cases. The formulas of Sutton or Bosanquet (1957), $\Delta = 0.09$, are not recommended. For many purposes the Davidson-Bryant, Holland, Bosanquet-Carey-Halton, or the remaining Bosanquet (1957) formulae would appear to be equally satisfactory.

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L. A. COUNTY CAR FLEET GETS CONTROL SYSTEM

All of the more than 3500 cars of the Los Angeles County fleet will be equipped with crankcase emission control systems that have been proved to be 100% effective in preventing air pollution from this source.

A pilot test program by County cars driving more than 1.5 million miles has shown that by the use on a vehicle of two systems, either of which alone is 80% effective, crankcase emissions can be controlled completely, and a safety factor exists should one system fail.

The test indicated that the devices had no significant adverse effect upon engine performance or maintenance. It had been anticipated that there might be an increase in deposits in carburetors or on values, but during the test these did not occur in excess of normal.

Two Basic Differences

The fundamental difference between the two systems is that one brings the crankcase emissions into the carburetor air cleaner, the other brings them into the intake manifold below the carburetor, which eliminates the possibility of deposits forming in the carburetor. In the latter system, a valve is necessary to maintain manifold pressure, and this increases the cost of the system and also requires periodic servicing.

Crankcase emissions have been found to account for about 20% of the total hydrocarbons emitted by automobiles. In recognition of this, all new cars sold in California in 1961 have been equipped at the factory with one type of crankcase emission control, as an "extra," but the devices are not yet required by law.

The Board of Supervisors has urged that the State make the 100% type of installation mandatory on new cars, and has directed the Air Pollution Control Officer to submit this system to the State Motor Vehicle Pollution Control Board for certification as acceptable.

Installation Costs Low

Control Officer S. Smith Griswold pointed out that installing the 100% system on new cars at the factory would add little to the cost. The presently installed 80% effective system on a new car carries a list price of about $5. The system to be added consists only of a piece of tubing and two inexpensive fittings to carry fumes from the valve cover to the carburetor air intake. This system has been used on many foreign cars for years, and installation at the factory involves a negligible added amount of material and labor.

For used cars, the County recommendation is that only an 80% effective system be required.

Flame Ionization HYDROCARBON ANALYZER*

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As technology in certain fields advances, the investigators in these fields occasionally find that the hydrocarbon, which has served them so admirably in the past, has now become an outright nuisance. One group may worry about minute traces of hydrocarbons as contaminants in their apparatus or process. Another group may be concerned with manipulating the hydrocarbons that they are using. A third group may fret about unwanted hydrocarbons being discharged into the atmosphere. These people all have a common problem; the rapid detection and measurement of a wide variety of hydrocarbon vapors and gases over a wide range of concentration.

As a result of the search for improved detector methods for gas chromatography, hydrogen flame ionization principles received a second look at a time when the general interest in trace hydrocarbon contamination widened. The appearance of the family of hydrogen flame hydrocarbon analyzers is the natural consequence of these two events. Hydrogen flame ionization will provide another tool for the hydrocarbon investigator whether he is interested in tenths of a part per million or thousands of parts per million concentrations.

The Principle

Briefly, the empirical basis for the flame ionization method is the observation that while the flame of pure hydrogen contains an almost negligible number of ions, the addition of even traces of organic compounds produces a large amount of ionization. In practice, the sample to be analyzed is mixed with a hydrogen fuel and passed through a small jet. Air is supplied in the annular space around the jet to support combustion. Any hydrocarbon carried into the flame results in the formation of ions which are accelerated to a collector electrode by an electric field set up between the jet and electrode. The generated ion current is proportional to the rate the hydrocarbon molecules are introduced into the flame. If flow rates are held constant, the ion current is proportional to hydrocarbon concentration.

Hydrogen flame detector response is found to be roughly proportional to the rate of introduction of carbon into the flame. Because there is some dependence of response on the chemical environment of the carbon in the original sample compound, it is convenient to express flame response in terms of an "effective carbon number." The effective carbon number for any compound can be estimated from a table of effective atomic number contributions. Table I based upon empirical data,[1] is such a listing of atomic contributions. From it, the molar response of a compound in the hydrogen flame detector can be estimated by summing the atomic contributions and multiplying by a proportionality constant characteristic of the burner configuration and operating conditions employed.

In this paper the proportionality constant for the Beckman Hydrocarbon Analyzer has been reduced to an equation in terms of percent of full scale reading on the most sensitive range. 2.5 (vol conc in ppm × C (equiv) × cc/min injection rate) = % full scale.

For example:

40 ppm of a C_1 injected at 1 cc/min; $2.5\ (40 \times 1 \times 1) = 100\%$ full scale. 1 ppm of a C_1 injected at 40 cc/min; $2.5\ (1 \times 1 \times 40) = 100\%$ full scale. 10 ppm of a C_{10} injected at 5 cc/min; $2.5\ (10 \times 10 \times 5) = 1250\%$ full scale ($42\% \times 30$ range).

The Instrument

The hydrocarbon analyzer consists of a regulated fuel, air, and sample delivery system, an internal burner, electronics for measuring the ion current, and in the portable instrument, an internal pump.

The ion current generated by the flame is measured by a transistorized, Vibrode stabilized ac amplifier. The amplifier output is displayed on a meter on the instrument front panel. Terminals are available at the rear of the instrument for connecting a 10 mv potentiometric recorder. The zero control supplies an adjustable current opposing the background ion current from the burner. This allows the baseline to be set at any point on scale, on any attenuation range for any level of background ion current. Range attenuation steps of ×1, ×3, ×10, ×30, ×100, ×300, ×1000, and ×3000 provide a dynamic range of 3000 without changing sample injection rates. Combinations of electrical attenuation and sample injection rates yield a range of sensitivities from one ppmC full scale to 25% C full scale. The ×3 range between the decade steps provides maximum readability on the meter. Zero is unaffected by range changes.

The flame is ignited by a hot wire filament located in the burner cap and is activated by push button on the instrument panel.

Figure 1 is a schematic flow diagram and schematic cross-section of the burner assembly. Because the sample is introduced internally to the flame with the fuel, the flame is not that of

Table I—Effective Carbon Numbers for Various Types of Atoms Indicating Their Approximate Relative Contribution to the Signal Produced in a Flame Ionization Detector. Aliphatic Carbon Taken as Unity

Atom	Type	Effective Carbon Number
C	Aliphatic	1.0
C	Aromatic	1.0
C	Olefinic	0.95
C	Acetylenic	1.30
C	Carbonyl	0.0
C	Nitrile	0.3
O	Ether	−1.0
O	Primary alcohol	−0.6
O	Secondary alcohol	−0.75
O	Tertiary alcohol, esters	−0.25
Cl	Two or more on single aliphatic C	−0.12 each
Cl	On olefinic C	+0.05
N	In amines	Similar to O in corresponding alcohols

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* Presented at the 54th Annual Meeting of APCA, Commodore Hotel, June 11–15, 1961, New York, New York.

pure hydrogen but hydrogen plus some inert carrier gas. The background current from the residual ionization, when no intentional hydrocarbons are being injected, is related to the physical properties of the flame, burner geometry, and hydrocarbon contamination in the fuel. Other than fuel contamination, linear velocity of the fuel emerging from the jet and hydrogen to inert carrier ratio are two important parameters which can alter the background ion current. In operation, this background current is electrically bucked out with the "zero" control, and readings are taken as difference between background, and sample plus background.

If the instrument is zeroed on pure hydrogen fuel and a sample in an inert carrier is injected into the fuel, the flame character is altered from both the change in linear velocity of the gases emerging from the burner jet, and the change in fuel to diluent ratio. Corresponding changes in background current and sensitivity can occur.

To reduce the uncertainties in analysis from these background and sensitivity deviations, it was decided to maintain constant burner conditions as nearly as possible for the various modes of operation. It was found that a mixture of about 40% hydrogen plus 60% inert diluent delivered at 75 to 85 cc/min (for the jet diameter used) gave the optimum signal to background deviation ratio. The cooler flame also reduces erosion of the burner tip and extends burner life.

One method of applying the instrument, then, is to deliver pure hydrogen to the burner at 30 cc/min and a fixed sample injection of 45 cc/min (40/60 ratio at 75 cc/min). This means that the burner must be supplied at all times with 45 cc/min of inert carrier, either as a reference gas, standard gas, or sample. "Zero" is set with the reference zero gas flowing; flow is switched to standard gas for calibration or sample gas for reading. This operation is performed external to the instrument, and is usually designed to suit the application. Momentary interruption of flow during switching will put a transient in the record, but recovery is immediate and does not affect the accuracy of the analysis. Attempting to zero by shutting down sample flow allows the flame to go to pure hydrogen at 30 cc/min and will introduce a baseline shift and a corresponding error in calibration.

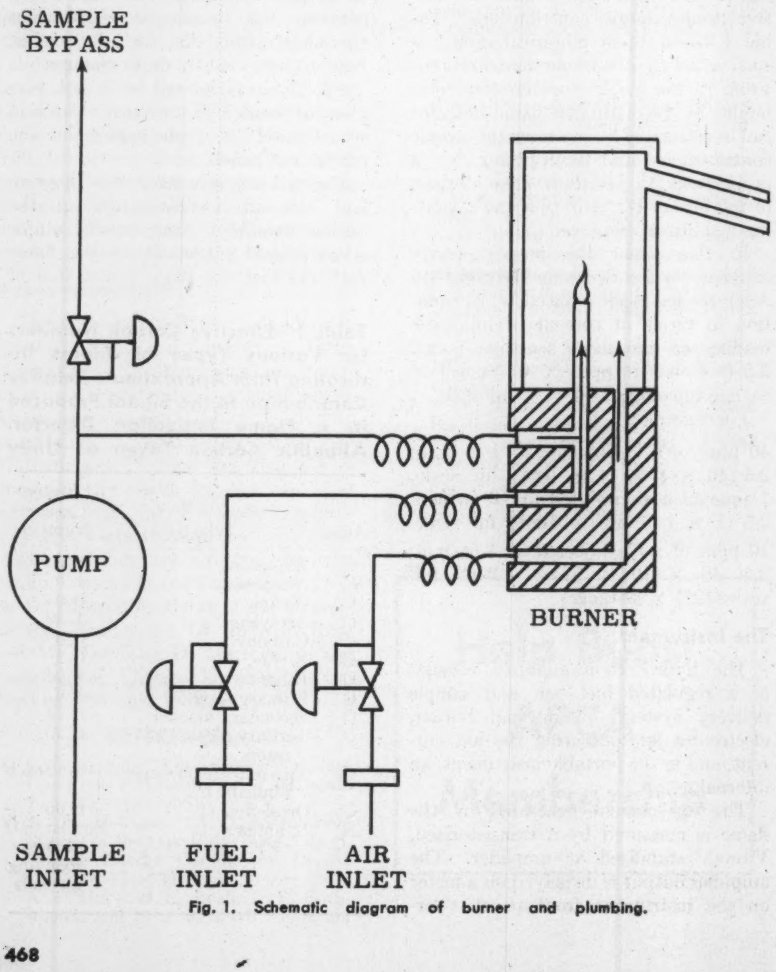

Fig. 1. Schematic diagram of burner and plumbing.

Materials which do not produce significant flame ionization but which alter the nature of the flame by their presence, act as interferants by distorting the relationship between the number of ions produced and the quantity of hydrocarbon in the flame. Also, high concentration of hydrocarbons injected at high rates tends to reduce the linearity of the flame. It can be seen that a high rate of sample injection (40 cc/min) is not always possible.

For applications where the high sample injection rate is not satisfactory, the hydrocarbon analyzer provides for an alternate method of application.

This method consists of supplying the burner with pre-diluted hydrogen fuel, and injecting samples at relatively low rates. Although almost infinite combinations of fuel mixtures and sample injection rates are possible, a nominal standard has been selected for these applications. Premixed fuel (cylinder) of about 40% hydrogen plus 60% nitrogen is delivered continuously to the burner at about 75 cc/min. Here it is not necessary to inject the sample or reference gas at all times because near optimum flame conditions for the burner are being met by the fuel alone. The sample may now be injected at very low rates of $^{1}/_{2}$ cc/min to moderately large rates of 10 cc/min, and readings taken. Because the percentage change in flame parameters is small at the low injection rates, it is not necessary to use a reference gas for zero, but to merely stop the sample flow. However, more accurate results are obtained again by using reference, standard, and sample gases injected at the same rates for zero, calibration, and analysis.

The latter method using premixed fuel is the most versatile mode of operation, and is considered standard for the hydrocarbon analyzer. This gives a carbon sensitivity up to four ppm full scale and is recommended for all applications except where higher sensitivity (one ppmC full scale) is required.

Accuracy and Source of Errors

The hydrocarbon analyzer contains the electronic stability to make use of the inherent sensitivity of the flame to hydrocarbons, but accurate analysis below 20 ppm carbon requires an understanding by the operator, of the external sources of error. Excluding the sample, there are two sources of unwanted hydrocarbons entering the flame; the burner fuel, and the air supplied to support combustion of the flame. At the present time it is nearly impossible to obtain hydrocarbon free cylinder gas. One to two ppm carbon is considered good. The burner produces an ion current equivalent to a full scale reading on the most sensitive range from 0.5 ppmC in the fuel. This amounts to 50 ppb volume concentration for a C_{10} hydrocarbon.

As explained earlier, ion current from sources other than the sample is considered background and is electrically suppressed. This does not significantly influence the accuracy of the analysis unless the background is excessive, that is, five ppmC or above in the fuel. However, the stability of the background does concern the operator. For example, an external source of drift may be traced to depletion of the fuel tank. Consider a 200 cubic foot cylinder of fuel depleted to about 500 psig and contaminated with a C_{20} fraction of pump oil. The vapor pressure of the C_{20} at room temperature can give a carbon concentration to the burner of about 0.4 ppm or nearly full scale on the most sensitive range. At the recommended fuel consumption rate, the tank will lose about one atmosphere for a 10-hour period. The change in hydrocarbon concentration is equal to about 10 ppbC or about two percent full scale increase in reading on the most sensitive range for the 10 hours.

Change in tank temperature will also alter the hydrocarbon concentration in the fuel. Pressure regulators and feed lines downstream from the fuel reservoir must be considered. Here temperature effects from materials absorbed in the regulator diaphragms can be critical. Purging of the offending regulator is not adequate; cleaning or replacement is necessary for precision work. By calculation it can be shown that there are enough carbon molecules in a drop of pump oil to drive the instrument full scale on the most sensitive range for a period of three years.

Attention must also be given to the burner air system, although the effect of hydrocarbon contaminants introduced in the air is about $^1/_{10}$ that of the fuel system.

What can be said about accuracy of calibration? Although flame ionization produces an ion current related to the carbon number of the hydrocarbon, the efficiency of ionization is determined by burner design parameters and the physical properties of the flame. Thus, at the present state of the art, calculation of the burner output in terms of ions produced vs carbon atoms in the flame is not possible, and burner sensitivity is determined with standard mixtures. Accuracy determined this way is a function of the skill in preparing standard mixtures and the care taken in selecting reservoirs for the standards. For work in low ppm concentrations, consideration of the container becomes very important, for in addition to expected wall equilibria with the added sample, desorption of unwanted hydrocarbons must be reckoned with. Unlike selective analyzers such as nondispersive infrared, the hydrocarbon analyzer is sensitive to all hydrocarbons; and the most difficult materials to remove, that is the high boiling, high carbon number compounds, yield the highest flame sensitivity. Vacuum pumping of a standard cylinder is not always adequate. For example: a C_{50} hydrocarbon on the cylinder wall in equilibrium with a good mechanical pump pulling 0.01 micron, will still leave a residual volume concentration of one ppb C_{50} or 50 ppbC equivalent. This amounts to 10% of the maximum sensitivity of the instrument. There are calibration and application techniques being studied which will provide absolute calibration for less than 10 ppmC, but until these methods are refined, attempts at accurate analysis below 10 ppm must be approached with some caution.

Because the attenuator range steps are linear and do not displace zero, it is possible to calibrate on 100 or 1000 ppmC, and operate on lower range settings such as 10 ppmC. This reduces some of the hardship of preparing 10 ppm and less concentrations in cylinders, but does not reduce the problem of obtaining a hydrocarbon free zero gas.

Sample Conditioning

The sample flow system consists of a pump, a back pressure regulator, a sample pressure gauge, and a sample capillary. The sample, at near atmospheric pressure, is brought into the instrument by the pump and compressed to a well regulated pressure. The sample by-pass regulator establishes a pressure from $^1/_2$ to $4^1/_2$ psig downstream from the pump and discharges the excess sample volume through the sample bypass. The pressure established by the back pressure regulator appears at the head of a 0.008 in. capillary which leads directly into the fuel stream at the burner base. Constant sample injection is maintained by regulation of the pressure drop across the sample capillary.

The internal pump brings the sample into the instrument at about one to four l/min to keep the initial response time of the instrument low. Also, the high volume flow through the pump and sample lines reduces the equilibration time for adsorption and desorption of the sample on the walls. The low cc/min flow which emerges from the sample capillary empties directly into the fuel stream in a small mixing chamber at the base of the burner jet. Thus, a fast initial response with minimum integration or tailing of the sample is achieved. Typical response times are four seconds for initial response and seven seconds for 90% of concentration.

To make full use of the inherent fast response of the hydrogen flame detector, no internal sample filter is used. However, it must be recognized that applications to samples containing aerosols or particles large enough to clog the 0.008 in. capillary will require filtering. In predicting the effect of a sample filter, the filter must be treated as added surface area in the sample line. The effect of the sample of trapped materials and condensate in the filter must also be considered. Filter design and choice of filter medium will be determined by the specific application. In applications where large quantities of suspended materials are encountered and extensive filtering needed, one can expect sample hold up in the filter and tailing in the record. Also, temperature changes in the filter will change the equilibrium between the sample and the filter surface, and produce transients in the record. Hydrogen flame has by no means reduced sample handling problems over other hydrocarbon analyzers such as nondispersive infrared. Indeed, because of the very sensitivity and versatility of flame ionization and its probable application to some unique problems, it may demand the development of new sample conditioning techniques. Fortunately, the applications which require high sensitivity are usually free from suspended solids, and often no filtering will be required. The "dirtier" applications such as engine exhaust analysis are usually concerned with higher concentrations (100 ppmC and above) where filter contamination is not as noticeable.

The Application

The hydrocarbon analyzer has generated considerable interest in air pollution control agencies, manufacturers of compressed gas, and users of high purity purge gas.

Compressor manufacturers and compressed gas suppliers have ordered instruments to monitor hydrocarbons in compressed gas and breathing oxygen. Missile manufacturers have ordered instruments for measuring purity of purge gas.

The first motor vehicle exhaust standards, set up by the California Department of Public Health, were based on available data on untreated exhaust composition obtained with nondispersive IR. The standard on hydrocarbons therefore defined that component as the "organic constituents of vehicle exhausts as measured by a hexane sensitized nondispersive infrared analyzer or by an equivalent method." However, until the "equivalence" or relationship between hydrogen flame and IR is determined, a complete substitution of instrumentation is not possible. As a result, a number of agencies and experimenters are now using both methods. Eventu-

(*Continued on p. 489*)

An Air Pollution PHYTOTRON*

A Controlled Environment Facility for Studies into the Effects of Air Pollutants on Vegetation

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Air pollution-induced injury in many species of vegetation is found in urban and industrial areas throughout the world. Numerous studies with controlled concentrations of atmospheric pollutants have shown that the field-observed injury can be duplicated in certain sensitive species by exposure to sulfur dioxide, "smog" gases, fluoride and miscellaneous fumigants. These studies have been primarily descriptive in nature: characterizations of typical foliar symptomatology, tables of relative sensitivity, etc. Few workers have explored the possible variations in physiological and biochemical responses of fumigated and unfumigated plants. The resultant literature has been the subject of many reviews.[1–4]

Most fumigation research has been subject to random as well as diurnal and seasonal variations in the plant environment, even though conducted under known and/or controlled concentrations of atmospheric pollutants. Thus it has been difficult to reproduce identical environmental factors, other than pollutant concentration, for subsequent days or experiments. Incomplete environmental control complicates the separation of air pollution-induced effects from other environmental effects, particularly in physiological and biochemical studies. Furthermore, under many climatic conditions work must be suspended during six months or more of each year because of reduced photoperiod, cloudy skies, low temperatures, etc. These difficulties may be resolved through use of a phytotron. The use of controlled environment chambers for plant research is firmly established.[5] However, the conduct of air pollution research in such a facility has not been adequately explored.

The random influence of environmental variables upon plant response to atmospheric pollutants is illustrated in unpublished data relating fluoride exposure to the polysaccharide and starch levels in *Pinus ponderosa* and *Prunus hortulania*.[6] Variations in starch content of the control plants shown in Figs. 1 and 2 indicate that daily changes in temperature, light intensity, etc., have a greater influence upon the range of starch variation than does fluoride exposure *per se*.

Therefore, it is essential to use controlled environmental chambers in the further study of the effects of any specific pollutant on plant behavior, because of the statistical difficulties involved in an adequate treatment of the many random, diurnal, and seasonal environmental variables including the pollution factor, all of which synergistically and/or independently affect plant behavior. Reproducible environmental conditions are required to obtain significant, quantitative measurements of a variety of physiological responses. Such reproducibility is only achieved in an environment in which all factors including the atmospheric pollutant levels are controlled.

A survey of many controlled environment installations revealed that none were specifically designed for the study of atmospheric gases on plants. The inherent design of these installations made it virtually impossible to provide a uniform concentration of an atmospheric pollutant around the plants.

This paper reports the design of a phytotron in which light, temperature, humidity, air circulation, and pollutant concentration may be adequately controlled for studying specific responses of plants to atmospheric pollutants.

The Chambers

Views and diagrams of the phytotron facility, constructed in 1956 in the Technology Building, Washington State University, are presented in Figs. 3 to 6. The total floor area of the phytotron is $8^1/_2$ by 20 feet. The $8^1/_2$ foot dimension permitted installation of the eight-foot long fluorescent tubes, tube sockets, and wiring ducts. This area was then divided into three walk-in type chambers. One larger area is $8^1/_2$ by 10 feet. The remaining space is divided into two chambers, each measuring 5 by $8^1/_2$ feet. All chambers are $7^1/_2$ feet high. The total volume of the three chambers is 1275 cu ft. The untempered masonite wall and ceiling paneling are painted with white Tygon paint for acid resistance and light reflectivity. One of the smaller chambers receives pollutant-containing air.

This three-chamber arrangement provides a large chamber for the germination and growth of a population of plants to any selected state of maturity. The population can then be divided into two groups (control and fumigated) and moved into the two smaller chambers for paired experimentation. Similarly, exposed and control plants could be moved from the two smaller chambers back into the larger chamber for observation for any specified time following termination of the fumigation experiments. This arrangement has been found to be extremely satisfactory.

The Air System

The major components of the air system are shown diagrammatically in Figs. 4 to 6.

Air Distribution. Most plant growth chambers are designed for introduction of the air at the bottom of the chamber. The incoming air is moved slowly upward and is exhausted near the ceiling. Furthermore, air is generally introduced into one end of the chamber and thence to an air exhaust at the opposite end, thus forcing the air to pass sequentially across the plants.

The rate of air flow required in a dynamic air pollution fumigation chamber is much greater than that used in conventional plant growth facilities.

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* Presented at the 54th Annual Meeting of APCA, Commodore Hotel, June 11–15, 1961, New York, New York.

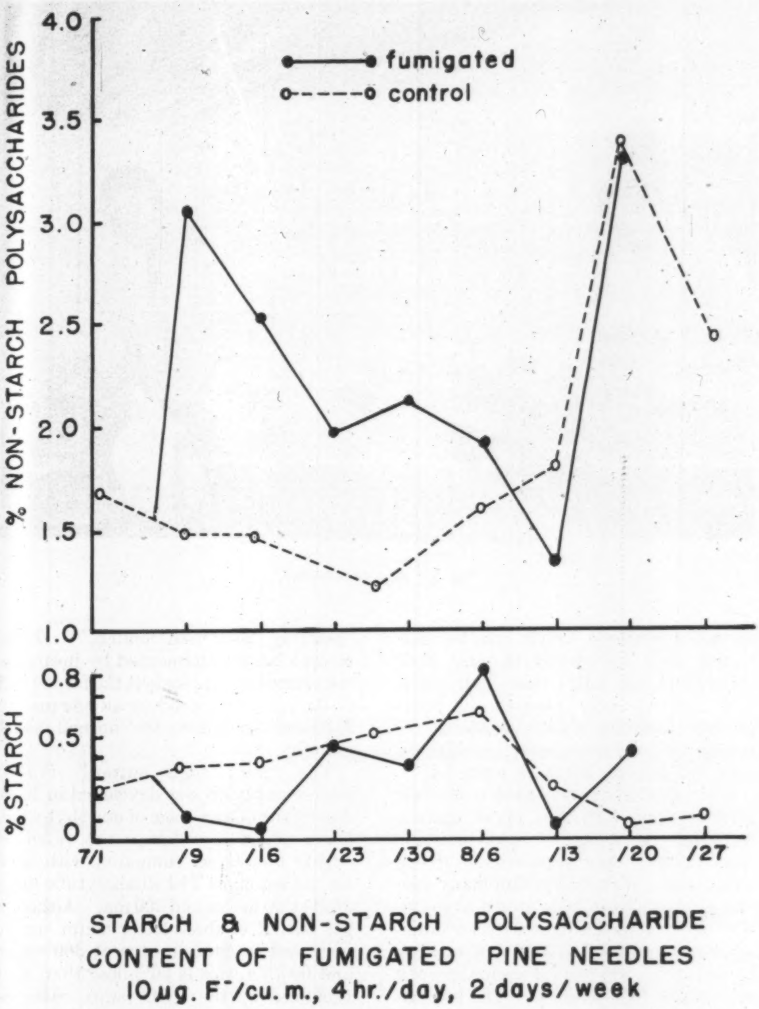


Fig 1. Starch and non-starch polysaccharide content of fumigated and control pine needles.

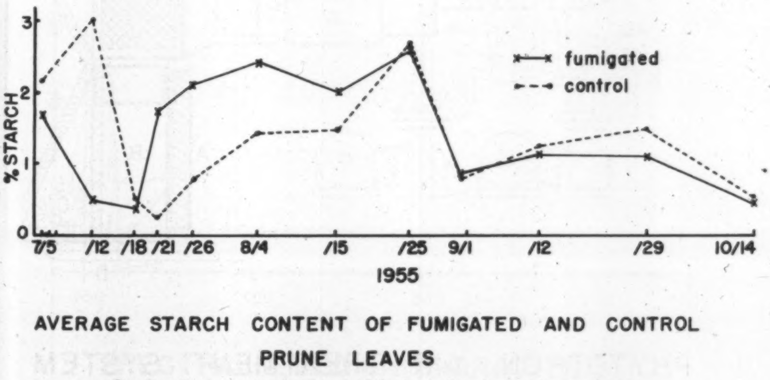


Fig. 2. Average starch content of fumigated and control prune leaves.

One to six air changes per hour is standard practice for conventional chambers,[5] whereas one complete air change per minute is a minimum acceptable rate of exchange for dynamic fumigation. Passage of such relatively high velocity air from below the shielding provided by the plant containers or table supporting the containers would induce a streamline flow around the foliage. Such a flow pattern prevents attainment of adequate equilibrium between the air and the leaves.

It is also essential that each "parcel" of air come into contact with only one plant as it passes through the chamber. Air containing a metabolizable pollutant cannot pass sequentially over a number of plants without becoming gradually and perceptibly lower in concentration.[7-8] Recirculated air cannot be used because of the obvious problem of maintaining a known pollutant concentration in the fumigation chamber. These problems are nonexistent in conventional growth chambers. Thus a new design is required for fumigation studies.

These chambers were designed to introduce the incoming air through the ceiling and exhaust the air through ducts at floor level. Air enters each 5 by 8½ foot section of ceiling through two air diffusers at the top of 12 inch high, top distribution plenums. The plenum floor (phytotron chamber ceiling) is constructed of Masonite "peg-board." The air is forced to enter the growth chambers through the numerous holes in the "peg-board" ceiling, thus creating a nearly uniform flow of air into the chamber. The exhaust ducts at floor level have a series of 1½ inch diam openings, longitudinally spaced, which assist in maintaining an even air flow through the chambers.

6

Air Movement. A double inlet, three horsepower blower ("G," Fig. 4) is located within the air duct downstream from the activated charcoal filter. A second, smaller blower is located at the end of the combined exhaust dusts. This latter blower increases the rate of air exchange through the chambers by 10 to 15% without developing a negative pressure in the chambers. This system provides a complete change approximately once every 53 sec.

Air Cleaning. The incoming air first passes through an Electro-Air Model 324H electrostatic precipitator ("B," Fig. 4), having a capacity of 2400–3000 cubic feet per minute. The tungsten ionizing wires carry 7500–8000 VDC to set up an ionizing screen which imparts a positive charge to all particles entering the cell. These particles pass into the collecting plate section, alternately charged 7500–8000 VDC and ground, and are deposited on the ground plate under the strong electrostatic forces. The deposited particles are flushed off

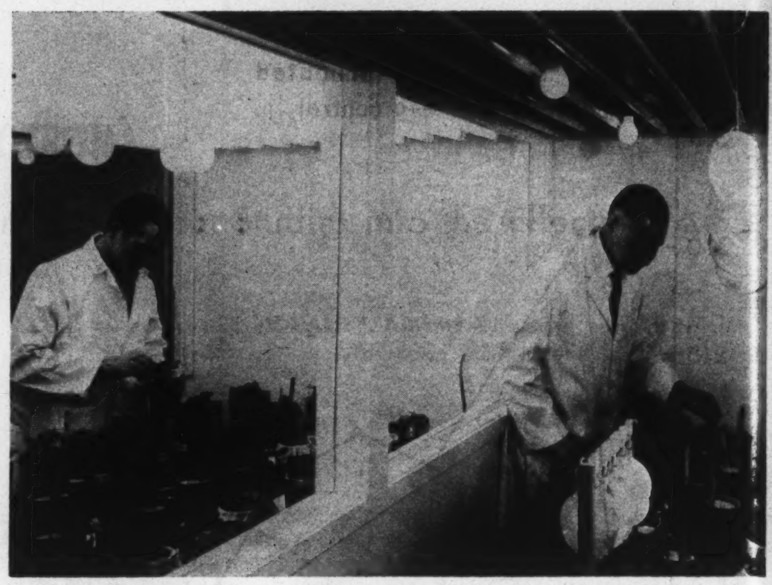


Fig. 3 Phytotron facility.

the collector plates weekly through drain "D" by washing the plates with hot water. Screen "A" (Fig. 4), $^3/_{16}$ inch mesh, was placed over the air inlet to prevent larger insects from being drawn into the electrostatic field and shorting the high voltage circuit. This screen also acts as an effective personnel safety shield.

The air then passes through a water curtain from four spray nozzles ("C," Fig. 4), to remove any water-soluble air pollutants. Two sets of mechanical filters ("E," Fig. 4), each two inches thick and filled with aluminum wool, prevent mist carry-over from the water curtain. In addition, the lower surface of the bottom filters is continually wetted by the spray, thereby providing additional contact between the water and soluble, airborne gases. The water passes out through drain "D."

The air next moves through activated charcoal filter ("F," Fig. 4) to remove any organic vapors. This filter is composed of 24 $18^3/_8$ by 19 inch filter panels assembled in a "V" arrangement. The capacity of this bank of filters is 2400 cfm. These filters contain activated coconut shell charcoal specially treated for the additional retention of ammonia vapors. The effectiveness of this charcoal was vividly demonstrated during the recent repainting of the interior of the Technology building. Although the incoming air carried appreciable quantities of paint solvent vapors, the vapors did not enter the phytotron.

The decontaminated air then flows through two sections of refrigerative heat exchangers. One exchanger "J," six rows deep, operated continuously. The second unit "H," four rows deep, is used on demand during the photoperiod. These heat exchangers are cooled by two three horsepower refrigerative compressors, "K" and "I." This equipment fulfills the dual requirements of dehumidification and cooling of the incoming air. The temperature of the heat exchangers is maintained at 34°F to prevent frost build-up on the coils. A third section of heat exchanger, "L," is connected to a 60 lb steam line to heat the air when necessary. Any necessary rehumidification is accomplished with an automatically controlled steam jet, "M," located in the air duct downstream from the heat exchangers.

A weekly schedule of mechanical maintenance of all equipment minimizes mechanical failure of motors, blowers, compressors, etc.

Illumination

Improvements in electric lamp technology during the past decade, including the recent development of high intensity fluorescent lamps, have made it possible to grow healthy, green plants under artificial light. Now plants can be grown to maturity indoors under environmental conditions which can be controlled and reproduced at any time throughout the entire year. Air pollution research may progress in plant growth chambers under year-long, reproducible environmental conditions, even in relatively northern latitudes.

The lighting levels needed for indoor growth vary with the plant species. Although the range of light intensity from the sun may approximate 10,000 foot-candles at its maximum, many species of plants have been grown to maturity under artificial light with an intensity range from 300 to 2500 foot-candles. Cereal grains will exhibit normal growth above 1200 foot-candles.[9] The Earhart Plant Research Laboratory was designed with an artificial light source of "possibly 2000 foot-candles."[10] Fluorescent lamps, augmented by incandescent lamps to supplement the far red end of the spectrum, produce an adequately balanced spectrum for normal plant growth.

The "very high output" (VHO) fluorescent lamp was developed in 1956, during the design stage of our phytotron. These eight foot lamps are rated at 13,500 lumens as compared with 4400 for the standard T12 slimline tube operated at 60 cycles and 300 ma. Although the output of these latter lamps can be increased to 6450 lumens at 360 cycles and 600 ma, this is 50% less than that produced by the VHO lamp. The increased light output afforded by the VHO lamp could be utilized in two ways.

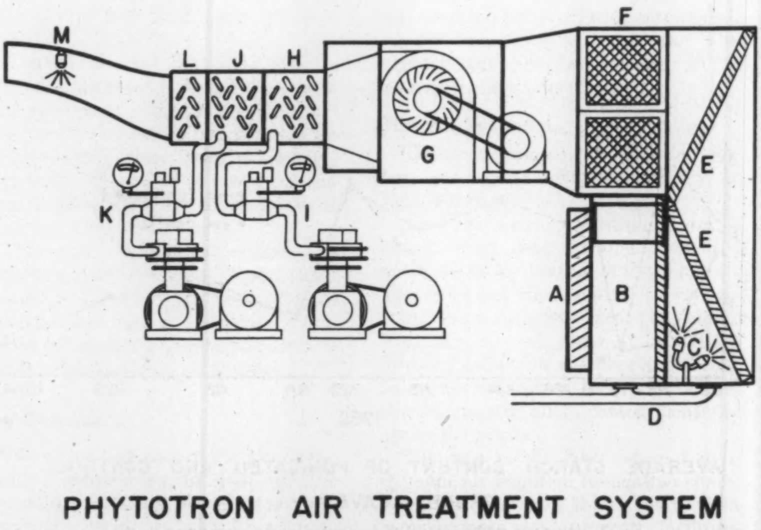


Fig 4. Phytotron air treatment system.

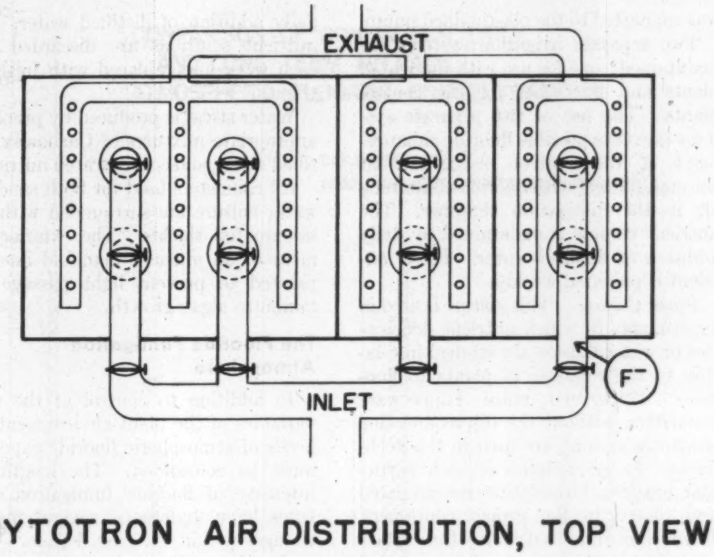


Fig. 5. Phytotron air distribution, top view.

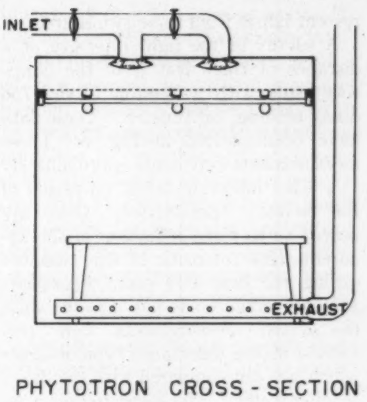


Fig. 6. Phytotron cross-section.

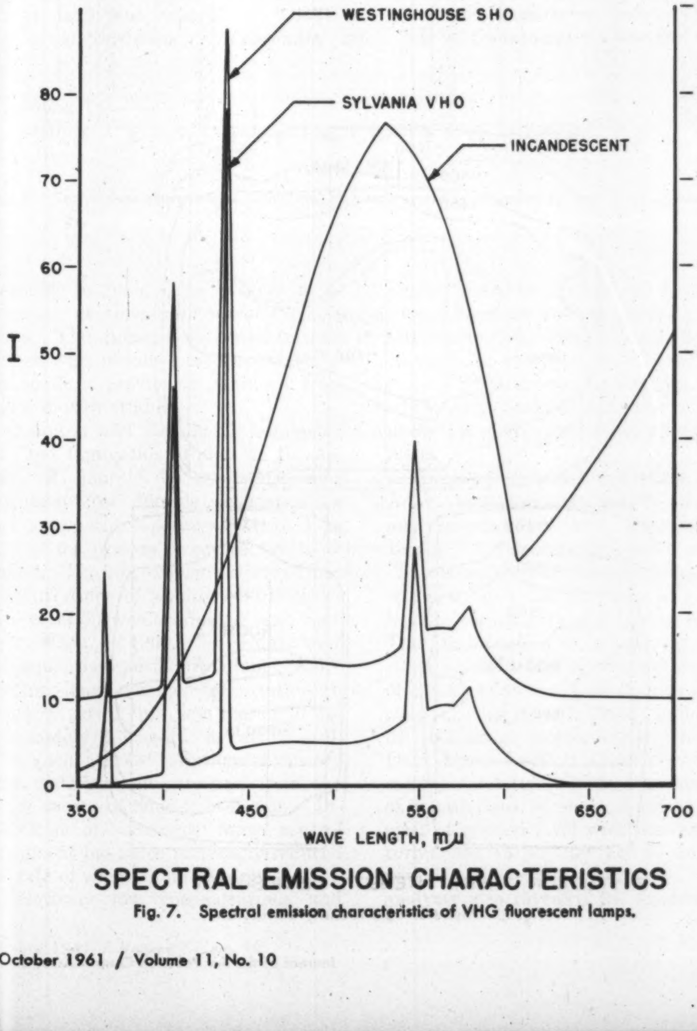


Fig. 7. Spectral emission characteristics of VHG fluorescent lamps.

VHO lamps could be spaced one inch apart as are the lower output lamps[11] to provide a potential light intensity between 3500 and 4000 foot-candles at a distance of three to five feet from the lamps. Alternatively the lamps could be spaced further apart to achieve approximately 2000 foot-candles of illumination.

This latter alternative permits some saving in capital expenditure; however, potential savings are not directly proportional to the numbers of lamps involved, since the VHO lamps and associated ballast are somewhat more expensive than the slimline lamps and ballasts. Recently, data have been published comparing the light output and cost for possible fluorescent lamp and ballast combinations.[12] These data show that VHO combination produced 93.7 lumens per square inch of lamp (the highest reported for any fluorescent lamp) as compared with 35 for the 60 cycle, 425 ma slimline lamp (the basis of comparison in these data). The ratio of foot-candles to base cost (the slimline installation) for the VHO lamp is 166% higher foot-candles for 126% higher cost. This appears to be the most favorable ratio of the nine improved combinations reported in this study.

The VHO lamps in this phytotron were mounted with 3$^1/_2$ inch spacing between lamps. The lamps were hung below the "peg-board" masonite ceiling. The ballasts were mounted on an external panel to reduce the heat load in the chambers. The ballast panel is cooled by means of two small fans to prevent overheating. One 60 watt incandescent lamp was installed for each pair of fluorescent tubes. The 13-hr photoperiod cycle is controlled by a Model 1196 Tork time switch.

The spectra of the Sylvania VHO and Westinghouse SHO fluorescent lamps and the 60 watt incandescent lamps were obtained with a Beckman DU spectrophotometer and are shown in Fig. 7. There is no apparent difference between the spectra of the fluorescent lamps from these two sources.

A survey of the light intensity at a distance of three feet from the lamps was made with a Weston Model 756 direct reading, light meter. These data have been plotted in Fig. 8. These measurements were made approximately $1^{1}/_{2}$ years following initial operation of the facility. Qualitatively, there appeared to be some reduction in the apparent light intensity of the chamber during the first $1^{1}/_{2}$ years' operation. Precise evaluation is not possible since the initial measurements were performed with a reflectance type of meter which was not compared with the direct reading meter. The suspected decrease in chamber illumination may be attributed to an overheating of the ballasts for a short period of time during the first summer's operation.

Heating of the incoming air as it flows over the lamps has been the primary difficulty encountered in this phytotron. Although the fluorescent lamp heat could have been dissipated by use of a water-cooled light filter[13] or an independent source of cooling air,[10] proper chamber air flow characteristics for air pollution fumigation study could not have been obtained. The problem was overcome by installation of a second stage of cooling. The incoming air is cooled to 45–50°F and the air is exchanged once every 53 sec. The maximum photoperiod temperature is in the range of 86–90°F.

Growing of the Plants

Sand Culture. Ottawa "flint shot" sand provides the mechanical support for the plants and their roots when large numbers of plants are grown in Hoaglund's nutrient.[14] A large volume of Hoaglund's solution is stored in a polyethylene crock at floor level. The nutrient is automatically pumped through a polyethylene-lined pump (Cole-Parmer, Model 5790) to individual 32 oz, sand-filled Tupperware polyethylene cannisters on the chamber benches. Four to six bush bean plants are grown in each container, depending upon the final state of maturity desired. Irrigation is automatically controlled with a Model 1196 Tork time clock adjusted to provide 5 to 15 minute irrigations per day. The nutrient returns by gravity to the storage crock, following each irrigation period. Aeration of the root system occurs as the nutrient drains out.

The cannisters were modified to permit bottom draining. Saran half-unions (5 to 16 inch diam) were installed in $^{7}/_{16}$ inch diam holes cut in the bottom of each container. A length of flared $^{5}/_{16}$ inch O.D. Tygon was connected to the Saran fitting with the Saran nut. Each container was connected to a glass and Tygon manifold located on each bench in the chambers. The manifold was connected to the plastic-lined pump.

Two separate irrigation systems are maintained; one for use with fumigated plants and the other for the control plants. The use of two separate systems prevents possible fluoride enhancement of the control plant nutrient through contact with fluoride-containing air in the fumigation chamber. The nutrient volume is maintained by daily addition of distilled water. Fresh nutrient is prepared weekly.

Water Culture. This culture is used in experiments in which nutrient deficiencies or water tension are studied in relation to the response of plants to fluorides. Thirty-two ounce Tupperware cannisters, without the interconnecting irrigation system, are used in this technique. Large volumes of each particular nutrient formulation are prepared and placed in the proper containers. Plants are supported above the surface of the nutrient by means of wax-impregnated cheese cloth "caps" having four to five small holes. The seeds are germinated to four to five days of age in moistened, filter paper-lined, borosilicate trays and then transferred to the wax-coated caps. The rootlings extend down through the holes in the cap into the nutrient. As the plants mature, the level of the nutrient is gradually lowered to provide root aeration. Nutrient solution volumes are maintained by the daily addition of distilled water. The nutrient solutions are discarded once each week and replaced with fresh nutrient.

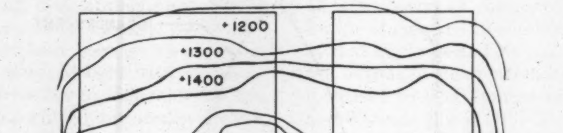
Water stress is produced by preparing appropriate mixtures of Carbowax, distilled water, and concentrated nutrient.[15]

All cannisters used for both sand and water culture are surrounded with aluminum foil shields. The exterior surfaces of all nutrient manifold lines are painted to prevent light passage and minimize algae growth.

The Fluoride Fumigation Atmosphere

In addition to control of the usual variables of the plant environment, the levels of atmospheric fluoride exposures must be considered. The length and intensity of fluoride fumigation exposures have undergone several marked changes within the past decade. Each major change in fumigation philosophy has usually followed a new development in sampling techniques for atmospheric fluorides.

The early studies of foliar response to fluoride fumigations were conducted for short periods of time at relatively high concentration levels. Several investigations of this type were reported at the Technical Conference of Air Pollution in 1950.[16–18] Meager analytical data on atmospheric concentrations were



PHYTOTRON LIGHT INTENSITY DISTRIBUTION

Fig. 8. Phytotron light intensity distribution.

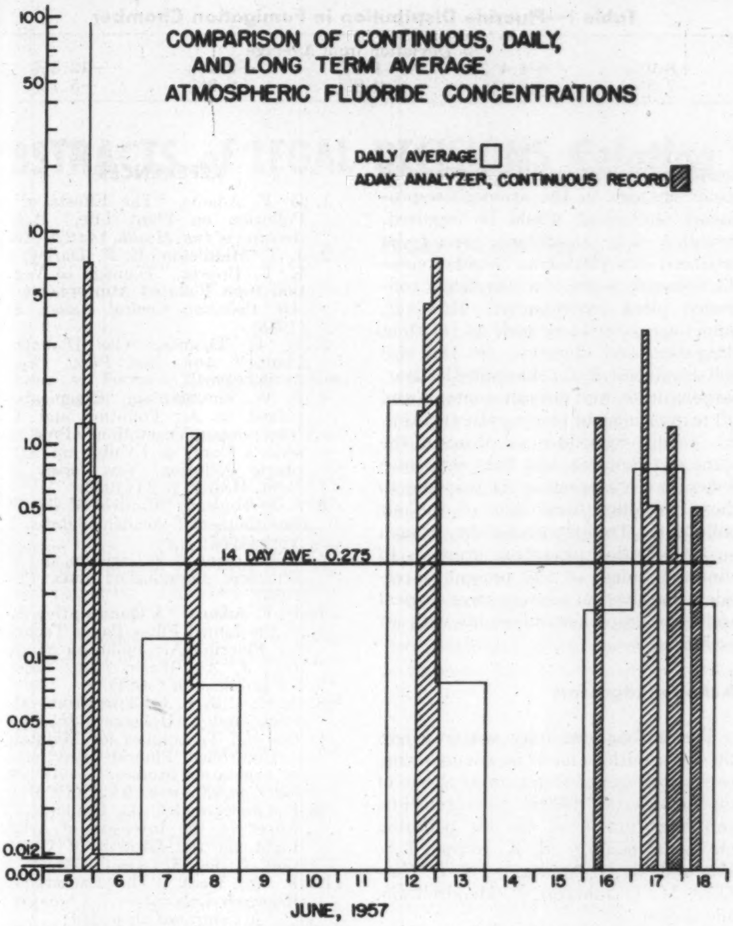


Fig. 9. Comparison of continuous, daily, and long term average atmospheric fluoride concentrations—a field study.

available to guide these workers in the selection of their experimental conditions. The fumigation concentrations chosen were usually based upon atmospheric data previously obtained from sulfur dioxide studies.

Compton and Remmert[19] conducted the first fumigation studies on the uptake of fluoride by gladiolus using extremely low fluoride concentrations and long term exposures (0.1 to 1 μg F$_-$/m^3 for periods of several weeks or more). The first extensive study of field concentrations of atmospheric fluorides in vegetation was conducted near Spokane, Wash., in 1950. These data were subsequently reported by Adams, et al.[20] Summer-long, average concentrations of fluorides varied from less than 1 to approximately 2.5 μg F$_-$/m^3 at 12 sampling sites. These variations correlated with distance and direction from the major source of fluoride pollution. Installation of extensive fume control equipment has since materially reduced the rate of emission in this area.

Relatively low concentrations and longer duration fumigation were employed by other workers following these disclosures.[19, 20] Virtually all fluoride fumigation research now being conducted by industrial, institutional, and educational research agencies is based upon this philosophy of exposure treatment.

The recent development of the Mini-Adak automatic hydrogen fluoride analyzer-recorder by Adams and Koppe[21-22] has revealed much of the "fine structure" of fluoride fumigation concentrations and durations at ground level in the vicinity of a typical source. The Mini-Adak automatically produces a continuous record in terms of the rate of change of atmospheric fluoride as the concentration is continuously influenced by changing meteorological factors. Data obtained with this instrument indicate that relatively wide concentration of fluctuations of short duration may exist at ground level with atmospheric turbulence (5 to 100 μg F$_-$/m^3 for periods of several minutes). This analyzer also revealed the existence of fumigations of lower concentrations (1 to 10 μg F$_-$/m^3 for longer periods from several minutes to several hours) resulting from diurnal, inland, summertime inversions or other atmospheric stability. The weekly average concentration of less than 0.3 μg F$_-$/m^3, obtained by averaging the Mini-Adak's continuous record, agrees with the previously accepted long-term average atmospheric concentrations determined by the older, integrated, bubbler tower sampling technique. These data are summarized in Fig. 9.

From these new data it appears that intermittent fumigations at higher levels would more accurately reflect field conditions than would continuous fumigation in the concentration range of fractional micrograms of fluoride per cubic meter. These concepts also apply to the selection of fumigation concentrations and exposure sequences to be used in studying plant response to other air pollutants.

Control and Analysis of the Fluoride Fumigation Atmosphere

Several techniques have been described in the literature for producing low concentrations of fluorides in fumigation chambers. Dilute mixtures, one to two percent HF in nitrogen, are easily prepared in evacuated stainless steel tanks, the final pressure being 400 to 500 psi. The mixture is introduced through a restrictive orifice at constant pressure into the incoming chamber air stream. This method was used by Setterstrom and Zimmerman[23] in sulfur dioxide fumigation studies.

A small volume of anhydrous HF can be measured in a gas buret, under paraffin oil, and transferred to a 19 liter flask coated with paraffin oil. Hydrofluoric acid is introduced into the air stream by displacement with paraffin oil from a small, constant volume metering pump.[24, 25] A third method involves the atomization and volatilation of fluoride solutions or known concentrations into a heated air duct.[26, 27] None of these methods has been found to be completely satisfactory for either continuous or intermittent use.

Hill, et al.,[8] described a procedure whereby air is first bubbled through distilled water and then through an aqueous solution of a volatile fluoride such as hydrofluoric or fluosilicic acids. The rate of fluoride emission remained constant over long periods of time when the temperature of the water and fluoride solution and the rate of air flow through the solution remained constant. The polyethylene bottles containing distilled water and hydrofluoric acid solution are located in a constant temperature bath. The exhaust tube, conducting the hydrofluoric acid vapors into the fumigation chamber air, must be continuously heated to approximately 150°F to prevent condensation of the fluoride and water vapor within the tube. This method has been used in this laboratory for more than four years and has been found to be extremely reliable.

Fluoride Distribution. The fluoride gradient throughout the fumigation chamber was established by exposing lime-treated filter paper in the fumigation chamber. The lime filter paper technique[7, 28–30] was chosen because of its simplicity. The longer exposures of the filter paper to the fumigation atmosphere parallel the longer exposures of the experimental plants and tend to reveal the same magnitude of differences anticipated from plant tissue analysis. The use of a similar number of bubbler towers or automatic analyzers would be much more expensive and might not reveal small concentration differences because of the relatively short sampling time.

Ten sets of lime-treated filter papers, six to a set, were hung in a grid arrangement above the bench in the fumigation chamber. The experiment was replicated six times. Each set of exposed papers was divided into two groups and analyzed separately. The data, tabulated in Table I, show that the ten bench locations have an average variation of ±5.9% from the mean, with a maximum deviation from the mean of −12.3% at one location.

These differences were attributed to lack of ideal fluoride dispersion in the air stream within the chamber. Fortunately, potential differences in fluoride concentration due to the presence of abundant vegetation are nonexistent in these chambers because of the unique direct air impingement air circulation design. The concentration gradient problem associated with abundant vegetation is described by Hill, et al.,[8] and has been shown to exist in commercial greenhouses wherein air moves along the plants.[7]

Diurnal variations of the chamber fluoride concentration have been found and are associated with variations in incoming air temperature. Greater adsorption of fluorides takes place on cooler chamber walls at night than occurs on the warmer walls during the daytime. The extent of this phenomenon has been demonstrated by continuous monitoring of the chamber air with the Mini-Adak automatic fluoride analyzer. The magnitude of the adsorption-desorption contribution to the diurnal fluoride concentration fluctuation is shown in Fig. 10.

Conclusions

The described facilities have been used in the study of the influence of atmospheric fluoride pollution on plant response. The design concepts and resultant equipment are equally applicable to similar plant studies using other atmospheric pollutants. Only relatively minor changes in the atmosphere-producing equipment would be required. So-called field conditions cannot be produced in a phytotron chamber since the objective is one of a completely controlled plant environment. However, numerous parameters such as (*a*) stem elongation and diameter, (*b*) leaf size and development, (*c*) chlorophyll, sugar, carbohydrate, and enzyme content, and (*d*) respiration and photosynthetic rates, etc., readily respond to all phases of the plant environment and thus introduce difficulties in separating the response to these variables from that of the air pollutant. Thus the availability of such an air pollution phytotron promises to eliminate much of the present uncertainty involved in relating physiological and biochemical measurements with air pollution.

Table I—Fluoride Distribution in Fumigation Chamber

% Deviation from Average				
−8.0%	+4.4%	−1.8%	+2.2%	−12.3%
−7.3%	+6.4%	+2.8%	+8.8%	+5.1%

Acknowledgments

The author gratefully acknowledges the contributions made by the following persons who assisted in various phases of the engineering design, measurements, and construction of the air pollution phytotron facility: R. K. Koppe, J. S. Englund, H. G. Applegate, R. C. Carriker, M. L. Johnson, R. Hendrickson, and others.

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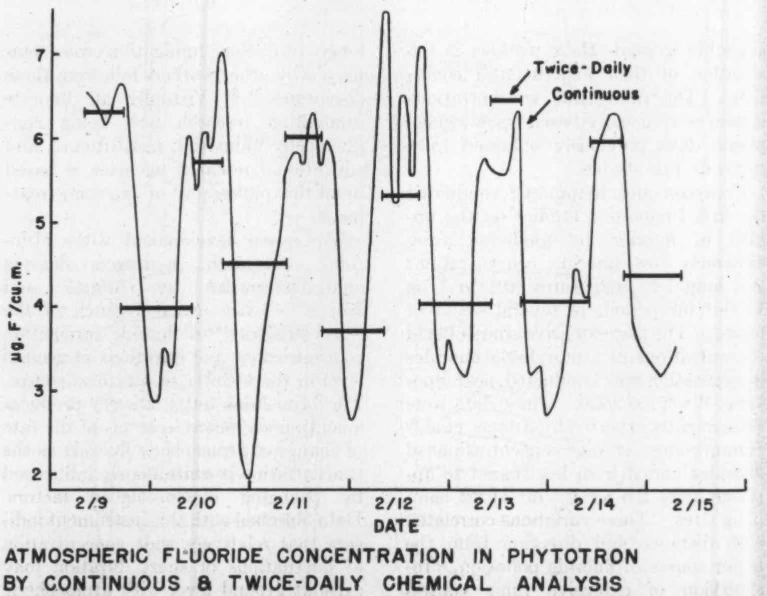

Fig. 10. Fluctuations in atmospheric fluoride concentration in phytotron by continuous and twice-daily chemical analysis.

ABSTRACTS *of* LEGAL DECISIONS *Relating to Air Pollution*

LEGAL COMMITTEE, E. E. SCHULZE, Chairman, Air Pollution Control Association

Bankston v. Farmers Co-operative Gin, 116 So. 2d 91 (La. 1959)

ACTION: For damages for nuisance.

FACTS: Defendant operated a cotton gin which emitted lint, mote, burrs, trash, dirt, and dust, through its discharge pipe. This discharge was permitted to spread and drift onto the nearby property. The dust also sifted through plaintiff's window screens. Several witnesses testified to this effect, and plaintiff's witnesses were not seriously controverted by the defendant's witnesses. A number of photographs were also introduced.

TRIAL COURT: Judgment for defendant.

APPELLATE COURT: Reversed the trial court and held that such activities constituted a nuisance and that the defendants were liable for damages. Defendant's only defense here was a general denial. The court noted that a property owner has the right to conduct a lawful business, but this business must be conducted with due regard for the rights of others. The court indicated that plaintiff's evidence supported the claim of nuisance and that $400 was a reasonable amount of damages. The court also noted that plaintiff's evidence was not sufficient on the question of damage to his hay crop.

Bennett v. Bagwell & Stewart Inc., 216 Ga. 290, 116 S.E. 2d 288 (1960). See also 107 S.E. 2d 824.

ACTION: For contempt.

FACTS: A rendering plant had been enjoined from operating in a manner which created foul and offensive odors. Plaintiff's and other witnesses testified that the odors were nauseating and interfered with their comfort and enjoyment of their property. Defendant offered witnesses who lived near the plant and didn't find the odors offensive. Defendant also had expert testimony to the effect that the odors could not have penetrated plaintiff's home. Defendant's witnesses also testified that there were other sources of odors in the area, i.e., chicken farming, etc.

TRIAL COURT: Judgment for defendant.

SUPREME COURT: Reversed the trial court judgment. The court noted that the question of whether or not the defendants were in contempt of the restraining order was one of fact to be determined by a jury. The court held that the charge that plaintiffs had the burden of establishing their right to have the plant closed if defendants were in contempt required a new trial.

No particular theory of defense was mentioned other than the fact that defendants had spent considerable sums to improve the operation of the rendering plant.

City of Birmingham v. Scogin, 115 So. 2d 505 (Ala. 1959)

ACTION: Suit against the City to enjoin the operation of a garbage dump.

FACTS: There was testimony in great detail by the plaintiffs and other witnesses to the effect that foul and obnoxious odors emanated from the dump; also that at certain times garbage was left exposed and uncovered. On the other hand, the defendant City's witnesses testified to the effect that garbage was never left uncovered, that there were no odors, and that the garbage dump was operated in accord with the best sanitary landfill methods.

TRIAL COURT: Granted a temporary injunction against operation of the dump.

SUPREME COURT: Affirmed and modified the injunction so as to limit it to fumes and odors. The court held that a nuisance created by negligence in the performance of a lawful function could be abated and that plaintiffs were entitled to an injunction against the unreasonable creation of obnoxious odors and fumes. The court further noted that the operation was not a health hazard, and therefore the entire operation could not be enjoined.

The court also noted that in Alabama zoning laws do not apply to the operation of a governmental function by a municipality. Likewise they noted that operating a garbage disposal area was a governmental function.

No theories of defense were mentioned, but from the law discussed by the court it appears that the City must have relied on some sort of "governmental immunity" concept.

Commerce Oil Refining Corp. v. Miner, 281 F.2d 465 (5th Cir. 1960)

ACTION: By oil refinery for injunction to prevent defendants from harassing and preventing plaintiff from constructing and operating its refinery. Defendants counterclaim seeking declaratory and injunctive relief against erection and operation of refinery.

FACTS: Plaintiff oil refiner intended to erect a refinery in the Town of Jamestown under a license from the local authorities and in an area of the town zoned for such use. There was a great deal of expert testimony offered by both parties as to the possibility of air pollution resulting from the operations of an oil refinery.

DISTRICT COURT: See 170 F. Supp. 396 (D.R.I. 1960). The District Court permanently enjoined plaintiff from erecting its oil refinery and held that the Zoning and Building Ordinance Amendments and the license issued thereunder were invalid, and that the refinery would be a nuisance when put into operation.

CIRCUIT COURT: The Circuit Court noted that the basis of the lower court's nuisance finding rested on other subsidiary findings to the effect that the oil refinery would cause air pollution. However, the fact that the refinery would act under the ordinances, whether valid or invalid, would be no defense to a charge of private nuisance by air pollution. The court concludes that there was no necessity for the lower court to consider the validity of the ordinances.

The court went on to discuss the expert testimony to the effect that oil refineries generate substantial quantities of malodorous gases, namely, sulfur dioxide, hydrogen sulfide, and a group of gaseous hydrocarbons called mercaptans. After discussing the deleterious effects of the latter two gases, the court noted that plaintiff's operation would be completely enclosed, and that air pollution would occur if there were some sort of accident.

The court then considered the effect

of discharge of sulfur dioxide. After discussing the conflicting expert testimony, the court noted that there would be detectable concentrations of sulfur dioxide for only about one or in every four-week period.

The court then cited Rhode Island cases to the effect that a home owner does not enjoy the absolute right to keep his neighborhood forever residential in character, and that no one is required to submit to his neighbor's unreasonable use of his property.

To secure an injunction against a neighbor's prospective use of his property, more must be shown than the mere possibility or even probability of harm resulting from that use. Unless the proposed use is a nuisance per se, injunctions are usually not granted to restrain anticipatory nuisances. After discussing several Rhode Island cases, the Circuit Court held that the District Court erred in enjoining the erection of plaintiff's refinery as a prospective nuisance. The court pointed out that on the relatively even balance of conflicting expert testimony, it thought the Supreme Court of Rhode Island would wait to see whether the refinery constituted a nuisance when put into operation.

The judgment of the District Court was set aside and the case remanded for entry of a judgment dismissing defendant's counterclaim.

Dept. of Health v. Roselle, 169 A.2d 153 (Sup. Ct. N. J. 1961)

ACTION: For contempt.

FACTS: The Department of Health made a motion for an order holding defendants in contempt for failure to comply with a final consent judgment ordering defendant to cease violating the New Jersey Air Pollution Control Code on premises which they operated as a refuse dump.

TRIAL COURT: Motion denied.

APPELLATE COURT: Found defendant in contempt and remanded. 60 N. J. Super. 363, 160 A.2d 864 (1960).

SUPREME COURT: Held that the restraint imposed by the prior judgment was too vague to sustain a finding of violation on the record.

COMMENT: The court spent most of its discussion on the law of contempt. In speaking of the merits of the case the court noted that likely causes of fires within the refuse dump other than the ones purposely started by the dump operators were: (*1*) fires started by strangers; (*2*) dumping of hot ashes; and (*3*) spontaneous combustion. The court recognized the "pressing dangers of air pollution" but went on to say that the Air Pollution Code did not require either an incinerator or sanitary land fill for refuse disposal. It should be noted that other New Jersey legislation now requires the land fill method.

Evans v. Moffat, 192 Pa. Super 204, 160 A.2d 465 (1960)

ACTION: For damages for nuisance.

FACTS: This action was brought by certain home owners against coal mine operators to recover for injuries to their homes caused by noxious and foul smelling gases which emanated from the mine refuse dumps. There was a great deal of testimony by the 25 plaintiffs and other parties to the effect, and the court so found, that the burning dumps give off hydrogen sulfide fumes and sulfur dioxide and carbon monoxide. The damp air and sulfur dioxide caused sulfurous acid to form in the air. This later oxidized into sulfuric acid. The hydrogen sulfide affected the paint on plaintiffs' houses, and when the wind blew over the dump the plaintiffs had "acid air" in their area. The various gases permeated the homes, causing headache and nausea to the occupants. The court also found that the injury caused by the air pollution was permanent because the dumps would burn for years.

The court makes no reference to expert testimony.

TRIAL COURT: Allowed plaintiffs $5700 damages in addition to the market value loss for annoyance and discomfort.

APPELLATE COURT: Affirmed the trial court and held that there was sufficient evidence to support the findings and conclusions of the trial court. The court relied on Restatement of Torts, §§822 and 826, which provides that an intentional invasion of another's interest in the use and enjoyment of land is unreasonable under the rule of §822, unless the utility of the actor's conduct outweighs the gravity of the harm. Here the court felt that the utility of the defendant's conduct did not outweigh the gravity of the harm done to plaintiffs. The court also makes reference to other sections of the Restatement. It is interesting to note that the court observed at page 473 that the most serious damage in this case was "the pollution of the air surrounding the houses."

Apparently defendant's only argument or defense was that certain other cases involving the same factual situation had disposed of the issues presented in this case, but the court disposed of this point by saying that the other cases were not *res judicata* because different parties were involved. Defendant also argued that there was no evidence on the cost of repainting the houses, but the court pointed out that this was a trivial matter compared to the other damages caused by the air pollution.

DISSENT: On the basis of another case for the same injury in which the Supreme Court refused to allow recovery, this case should be reversed. See 109 A.2d 310.

Fairview Farms, Inc. v. Reynolds Metal Co., 176 F.Supp. 178 (D. Ore. 1959)

ACTION: By operator of dairy farm against aluminum reduction plant for damages.

FACTS: Defendant operated an aluminum reduction plant nearby the plaintiff's dairy farm. In producing aluminum, certain airborne gases, liquids, and solids containing fluorides were emitted. The defendant continually was improving its operation so as to cause less air pollution.

TRIAL COURT: Held that dairy farm had a good action for trespass and that the Oregon six-year statute of limitations controlled.

The court reasoned that this cause of action was a trespass since matter was actually deposited on the plaintiff's land. Also it appeared that the court was concerned with using the six-year statute of limitations rather than the two-year statute which applied to nuisances. The court further said that trespass and nuisance were not mutually exclusive actions. The court awarded damages to plaintiff for injuries to the dairy herd and loss of milk. The defendant had already paid for damage to the foliage on plaintiff's property.

Reynolds denied plaintiff's contention and said that the damage involved was *de minimus*, that they had already paid for the damage done; and that if they were liable it was for nuisance and therefore plaintiff was barred by the two-year statute of limitations. As noted above, the court disposed of the trespass nuisance problem and held that the payments by Reynolds were only for damage to the hay and grass and foliage on plaintiff's property. The court further indicated that plaintiffs could be adequately compensated by damages and that no injunction was warranted.

Harless v. Workmen, 114 S.E. 2d 548 (W. Va. 1960)

ACTION: For damages for nuisance.

FACTS: Defendants operated a coal loading tipple and coal crusher, which caused dust to be emitted into the atmosphere. Plaintiff alleged that this dust was an atmospheric contaminant, and that the operation of the tipple and the coal crusher was a nuisance. Plaintiffs alleged that dust entered their homes but there was a conflict of testimony on this point. Defendant showed the precautions they had taken to keep dust down. Sprinklers and spraying systems were installed on the

(*Continued on p. 489*)

Incinerator FURNACE TEMPERATURE*

How to Calculate and Control It

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This paper covers the recommended procedure and factors of primary importance in the design and operation of a refuse incinerator, so as to be able to calculate and maintain the optimum furnace temperature. The procedure has been simplified as far as possible.

The three "T's" of combustion, namely "time," "temperature," and "turbulence" are so closely related that they must be considered together in determining the performance of the incinerator. Without time enough for the combustible matter to burn, the desired temperature will not be obtained, and without adequate turbulence neither the time or temperature requirements will be met.

For any given furnace and fuel there is a fairly definite and rather easily determined optimum furnace temperature which can be calculated, when certain controlling factors are known or assumed. Such calculations have been used for many years in the design of boiler furnaces but are not so well known or understood in the case of incinerator design.

These factors include the fuel characteristics such as ash fusion temperature and moisture content for solid fuels; also unit heat value, as well as the furnace size and design, water cooling, or refractory wall construction, including boiler or other heat absorbing or "black" surfaces. The S/V ratio or heat absorbing surface vs furnace volume is sometimes used to express the latter factor.

The principles involved are the same for any fuel, but for our purposes here we will go through a typical calculation for an incinerator designed to burn municipal or industrial refuse. The moisture content in a solid fuel such as refuse, cannot be readily measured or controlled. However, the total air flow is quite easily regulated, and is the major factor in carrying away the heat generated, and controlling the furnace temperature, as the attached heat balance calculations and charts illustrate.

The maximum furnace temperature in any combustion process is of course obtained when the theoretical air only is supplied. In the case of most fuels including refuse this temperature will be well above 3000°F, which greatly exceeds the allowable value for practically all solid fuels because of ash fusion and clinkering properties.

The excess air introduced into the furnace has therefore been used for years to directly control the furnace exit gas temperature. For most incinerators this has required from 100% to 200% excess, for the all-refractory furnaces normally used, with substantially less air when water cooling is provided. Possible advantages of water cooling will be considered in subsequent sections of this paper.

The radiation loss seldom averages more than one to three percent of total heat input and depends largely on the furnace wall construction and temperature differential between furnace and ambient air. Heat absorbed in the brickwork of the furnace before stable conditions are obtained is a function of the weight of brick involved, temperature rise, and specific heat of the brick and seldom exceeds five percent even when starting with a cold furnace.

The hottest part of any furnace is in or near the top of the flame, where combustion to CO_2 has been completed. The flame itself is therefore the hottest arch possible and should be permitted to burn out directly above the refuse on the grate to assure rapid drying and ignition.

When a pound of carbon burns only to CO, it liberates 4450 Btu or about $^1/_3$ of its total heat, the latter being liberated only when the carbon burns to CO_2.

Furnace size has a rather secondary effect on the temperature obtained, as it is possible to obtain practically the same flame temperature over a two to one or more range in heat release rates. That is, for a given burning capacity the furnace size can vary quite widely, without material effect on the temperature, provided the excess air is carefully controlled.

All fuel, whether solid, liquid, or gaseous, actually burns largely as a gas, the heat from the furnace serving to dry out the moisture and volatilize combustible matter from the fuel bed.

The following discussions and tabulations illustrate the above points for a typical size of incinerator of the direct fed type.

It should be noted that complete combustion of cellulose fuels such as refuse can be accomplished with 50% or less excess air as is the case in the installation where water walls have been installed, either with or without accompanying boilers. There is therefore plenty of leeway in the use of cooling air, with the general understanding that the least possible excess air

Refuse assumed to have 20% moisture, 6000 Btu per lb			
Refuse burned per hr, 1000 lb			
Burned with 200% excess air			
Gas temperature in furnace, 1600°F; ambient temperature, 70°F			
Heat loss in combustion products	5,430,000 Btu	90.5%	of input
Heat loss by radiation through walls	156,000 Btu	2.6	of input
Heat loss by air leakage through walls	180,000 Btu	3.0	of input
Heat loss from unburned combustible and unaccounted	234,000 Btu	3.9	
Total heat losses	6,000,000	100.0%	
Total heat input 1000 × 6000	6,000,000		

Fig. 1. Heat balance, refuse burning.

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* Presented at the 54th Annual Meeting of APCA, Commodore Hotel, June 11-15, 1961, New York, New York.

Wall Construction	Cold Face Temperature, °F	Radiation Loss, Btu/sq ft/hr
4½ in. plastic	440	1356
9 in. plastic	319	730
4½ in. plastic +1 in. insulation	262	495
8 in. plastic +4 in. insulation	153	150
9 in. firebrick +8 in. red brick	274	545

Fig. 2. Effect of furnace wall construction on outside or cold face temperature with 1600°F furnace temperature.

should be supplied compatible with furnace maintenance, to avoid undue cooling, and excessive gas velocities, which directly affect fly ash or particulate emission.

There are three ways only for the heat generated by the burning refuse to escape from the furnace as outlined below:

1 It can be carried away in the combustion products, which include the air admitted under and over the fuel bed as well as the weight of the combustible part of the refuse, and its moisture content.

2 Some of the heat will be absorbed in heating up the brickwork during the initial start up, and lost by radiation from the outside walls of the furnace, when equilibrium has been established.

3 The balance will be lost by air leakage through cracks in the setting and around doors, and unburned hot residue which drops into the ash pit.

In a heat balance as in the army, all units must be present or accounted for, hence at the end of such a tabulation, there is usually an item covering the difference between the calculated losses and the total heat input from the burning refuse. When there is no such excess of input over losses, then we can expect the furnace temperature to drop below the desired minimum.

In the determination of any form of heat transfer we are constantly using the specific heats of the various mediums involved, so a brief discussion of this factor is believed desirable.

Specific heat or the Btu required to raise temperature of one lb of substance one degree F is a valuable tool, too often overlooked or misunderstood by incinerator designers. Yet its vital function is well illustrated in the heat balance Fig. 1, which shows what happens to the heat generated in the furnace by the burning refuse or auxiliary fuel.

This heat is never lost or dissipated as is sometimes assumed by inexperienced designers. In order to cool a gas, for example, the excess heat must be transferred to some other medium, such as air, refractory material, or water walls.

Every medium, whether solid, liquid, or gas, has its specific heat value, which is dependent on the temperature and pressure involved. Engineering handbooks give the specific heats of the products of combustion commonly experienced, as well as of the furnace materials used. These values are of course compared to that of water which is taken as 1.0 or unity, and are taken at atmospheric pressure.

For our purpose the specific heat may be considered as the ability of the various mediums involved to absorb and carry away the heat generated by the incineration process, which heat may be transferred later to some other medium for instance, by means of a heat exchanger.

Water, with a specific heat of 1.0 will pick up and carry out four times as many Btu per lb, as will air, having a specific heat of 0.25. This is one reason why water is such a popular heating and cooling medium, and why it is sometimes used instead of air for reducing the gas temperature from incinerator furnaces.

When we increase this excess air to say 250%, the heat loss in the combustion products alone increases to 6,350,000 Btu per hr, which combined with the other losses, adds up to 6,920,000 Btu, or considerably more than the total heat input, so that the furnace temperature drops, as shown in Fig. 3.

The radiation loss of 2.6% can be reduced by use of an insulated setting, to perhaps 1½%, or increased to four or five percent if the setting is reduced in thickness. In the latter case the outside wall temperature would be so high that the operators would be endangered. The close relationship between furnace construction and outside temperature is clearly illustrated in Fig. 2.

It is evident from the above heat balance that by far the greatest and most easily controlled loss is that due to the air flow into and through the furnace. We cannot change the radiation loss without rebuilding the furnace, and the moisture loss is determined by the refuse itself, which generally must be taken as it comes. Hence the emphasis for good incineration must be put on the fuel-air ratio, or the amount of combustion air admitted to the furnace in a given time.

In the above example the heat loss, by transfer to the moisture in the refuse, amounts to 362,000 Btu per hour, or 6.05% of the total heat input. Control of this moisture and resultant heat loss is desirable but usually difficult or impossible, hence as noted above the most practical way to regulate furnace temperature is by means of the entering combustion air.

Contrary to popular belief, the major function of the walls and roof of the furnace is not to reflect the heat back into the furnace, but to direct the gas flow and prevent the admission of uncontrolled cold air. Even in a re-

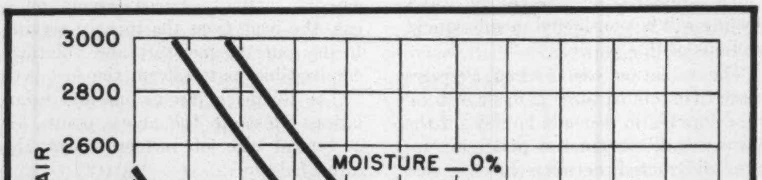

Fig. 3. Relationship between moisture, excess air, and furnace temperature.

fractory furnace, the wall temperature is always somewhat cooler than the flame temperature, except perhaps for a few moments after the fire is cleaned or the heat input is otherwise suddenly reduced. Heat will flow only from high to low temperature, and unless the walls are at a higher temperature they cannot reflect heat back to the flame.

This was proved definitely years ago, with the advent of water wall furnaces, many of which now have no refractory at all next to the fire, yet such furnaces can be and are operated at higher temperatures because there is much less trouble with slagging or refractory maintenance.

Similarly the heat-up time required is affected much less by the furnace wall construction than by the control of the fuel-air ratio during this period. The belief that the heat absorption by the cold refractory furnace walls materially delays the obtaining of full furnace temperature is also refuted by experience with water wall furnaces, in which the heat absorption per square feet per hour is at a much faster rate—possibly 30 times—and which never gets above the water temperature of several hundred degrees F, yet in practice such furnaces reach full operating temperature within a comparatively short time. This time interval is usually determined by allowable expansion stresses rather than firing rate as any experienced operator knows.

It is true that a considerable amount of heat is absorbed by the refractory walls in a cold start, and that it may be several hours before full wall temperature is reached. Calculations show that about 8,600,000 Btu are absorbed by the refractory in the example furnace, but it may take 10 hours or more for this heat loss from the furnace to occur, during which time the excess air flow, and resultant heat loss in the combustion products, may be correspondingly reduced.

Radiation losses do not start until the outside wall temperature has risen appreciably above the ambient air, so that such losses are negligible during the warm-up period.

The desirability of closing all doors and dampers to avoid undue cooling of the refractory walls, during idle periods is apparent.

Furnace size and design do of course affect incinerator performance in several ways. When the furnace is too small,

Effect of Oversize Furnace (Double Normal Size)	
Refuse assumed to have	20% moisture
Refuse assumed to have	6000 Btu pr lb
Refuse burned per hr	500 lb
Refuse burned with	200% excess air
Gas temperature in furnace	1600°F
Ambient heat input	70°F
Total heat input	500 × 6000 = 3,000,000 Btu/hr
Heat lost in combustion products	2,715,000 Btu/hr
By radiation through walls	156,000
By air leakage through walls	180,000
From unburned combustible and unaccounted	117,000
Total heat losses	3,168,000
Total heat input per above	3,000,000 Btu/hr
Furnace temperature will decline as input is less than output	
Ditto with excess air reduced to	150%
Heat lost in combustion products	2,300,000 Btu/hr
Heat lost by radiation through walls	156,000
Heat lost by air leakage through walls	180,000
Heat lost from unburned combustible and unaccounted	117,000
Total heat losses	2,753,000 Btu
Total heat input per above	3,000,000 Btu
Furnace temperature will hold or rise as input is greater than output	

Fig. 4. Heat balance, refuse burning.

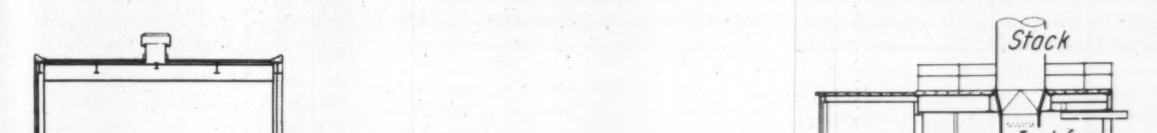

Fig. 5. Large municipal incinerator with traveling grates and automatic control.

combustion cannot be completed until some of the volatile combustible matter has passed over the bridge wall, because of lack of the "time" factor noted above. The heat-up time for such a furnace can therefore actually be delayed, as the heat generated in the secondary chamber does no good in heating the primary furnace. In the case of a high moisture refuse, this heat loss can seriously reduce the incinerator capacity, as a considerable amount of heat is required to dry out and evaporate this water content.

A check of the steam tables will show that it takes 1810 Btu to heat a pound of water from 70°F to 1600°F, or 30% of the 6000 Btu available in our example refuse. Both theory and practice show that at something over 70% moisture in the refuse, the latter ceases to be "auto combustible," and that relatively expensive auxiliary heat is required to maintain the furnace temperature. This is illustrated in Fig. 3, where the theoretical maximum temperature with no excess air or other heat losses is only 1900°F, and at 50% excess air the temperature has already dropped below our 1600°F level.

The effect of an oversize furnace is easily shown by assuming that the amount of refuse burned per hour is reduced by half, together with the combustion air introduced into the furnace. The radiation loss will remain the same, assuming that the furnace temperature is maintained, and air leakage through the brickwork and around doors will also be unchanged. When these constant losses, added to the loss in the combustion products, are greater than the heat input, then the furnace temperature will drop, and incineration efficiency will drop unless the excess air is reduced as the following example illustrates. (Fig. 4.)

While it is generally easier to obtain good performance with an oversize furnace as compared with one which is too small, there are several factors which limit the desirable size for a given capacity. Perhaps foremost is the cost, which would normally affect materially the incinerator selection. It is also more difficult to avoid air leakage through the walls and doors of an oversize furnace, and the radiation loss will of course be higher because of the greater wall area.

In the very large boiler furnaces now common, the entire furnace is made practically airtight by means of welded steel tubes and casings, with heavy layers of insulation to reduce radiation loss. Many of the new boilers are designed and operated with a positive pressure in the furnace, to further reduce the infiltration of cold air, as well as to eliminate the need for an induced draft fan.

Such construction details would be much too costly, or otherwise impractical for an incinerator, so the design should be proportioned to obtain the optimum performance for the required capacity at minimum cost.

Automatic combustion control equipment is very helpful in maintaining the desired furnace temperature, as the temperature sensing device can be used to regulate the total air flow to the furnace, in accordance with requirements.

For example, if the temperature starts to fall, the total air flow will be reduced by means of the forced draft fan damper, until the temperature is stabilized at the desired point. The reverse action will be taken as soon as the temperature rises unduly, and this regulation can be accomplished much more quickly than the average operator would be likely to react.

Such controls should also incorporate a barometric or other damper to maintain the desired low furnace draft at all times to minimize the air leakage into the furnace.

Care in the use of the charging door, and in raking the fire, as well as in cleaning out the residue, is also beneficial, as the rush of cold air into the furnace is very detrimental, lowering the gas temperature and chilling the brickwork. The development of automatic feeding devices to facilitate charging at a uniform rate, preferably without having to open the charging door, is recommended.

The large municipal incinerators using traveling grate or similar stokers, wherein the refuse hoppers are kept full by the operator, and the stoker movement controls the feed rate, show what can be done in this respect. See Fig. 5.

The skill of the operator is still a major factor as regards satisfactory incineration, and a proper training and supervising program is essential.

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RELATIONSHIPS *Between 24-Hour Mean* AIR QUALITY MEASUREMENTS *and* METEOROLOGICAL FACTORS *in Nashville, Tennessee**

D. Bruce Turner, Weather Bureau Research Station, Laboratory of Engineering and Physical Sciences, R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio

This study was undertaken to determine how well daily city-wide air quality measurements can be related to some easily obtained meteorological parameters affecting source strength, dilution, and dispersion of pollutants.

As part of the Community Air Pollution Study in Nashville, Tennessee, 24-hour air quality measurements of sulfur dioxide and soiling index were made at 32 locations in the urban area. Sulfur dioxide concentrations in parts per hundred million were determined using bubblers and the West and Gaeke analytical technique and soiling indices in C* (COH/1000 ft) were determined using strip filter paper samplers and a spot evaluator to measure light transmission.[1], [2] Solutions and filters were changed at approximately 1400 CST each day. Daily city-wide sulfur dioxide concentration, SO_2, was obtained by using the 32 station arithmetic mean. Daily city-wide soiling index, C*, was similarly defined. These measures of city-wide air quality minimize the effects of topography, wind direction, inhomogeneity of sources, and exposure on individual stations.

Since most of the sulfur dioxide in Nashville is the result of combustion of fuels for space heating,[3] the heating degree day is expected to give an indication of city-wide sulfur dioxide source strength. Degree days will not give as good an indication of sources for soiling index since there are numerous other sources besides those related to space heating that affect soiling index. Due to the heat capacity of buildings, a lag may be expected between temperature changes and heating levels. For convenience the degree day value, for the calendar day on which the measurements started, was used thus allowing for a lag of 14 hours between temperature and its effect on air quality measurements.

Both dilution and dispersion due to wind speed and stability conditions should affect air quality. Since no vertical temperature difference measurements were available in Nashville, some other indication of stability is used. Stability is mainly dependent on net radiation and wind speed. Net radiation is affected by altitude of the sun, and cover and thickness of the clouds. A system of hourly stability classification, suggested by Pasquill,[4] was objectively defined using wind speed and estimates of net radiation derived from solar altitude, and measurements of cloud cover and ceiling (see Appendix). Stability indicators range from one, extremely unstable, to seven, extremely stable. A daily stability indicator, $\bar{s}$, was defined as the arithmetic mean of the 24 hourly stability values over the sampling period. Similarly, the mean wind speed, $\bar{u}$, is the arithmetic mean of the hourly airport measurements of wind speed for the sampling period. If no dispersion takes place, air quality would be inversely proportional to wind speed. Therefore values of $1/\bar{u}$ were also calculated.

The 182 consecutive days from October 2, 1958 to April 1, 1959 were selected as the data to be used for this study and were divided into two groups in the following manner. The data were ranked according to SO_2. The odd numbered rankings were defined as group 1, and even numbered rankings as group 2.

Table I—Correlation Coefficients, Group 1

	DD	$\bar{s}$	$\bar{u}$	$1/\bar{u}$
SO_2	0.73	0.55	−0.45	0.36
DD	—	0.18	−0.15	0.04
$\bar{s}$	—	—	−0.72	0.64
$\bar{u}$	—	—	—	−0.82
C*	0.58	0.59	−0.52	0.46

Using group 1 data, scatter diagrams were plotted and linear regression lines determined for the following:

1 SO_2 against degree days (DD), Fig. 1.
2 SO_2 against 24-hour mean stability ($\bar{s}$), Fig. 2.
3 SO_2 against 24-hour mean wind speed ($\bar{u}$), Fig. 3.
4 SO_2 against $1/\bar{u}$.
5 C* against DD, Fig. 4.
6 C* against $\bar{s}$, Fig. 5.
7 C* against $\bar{u}$, Fig. 6.
8 C* against $1/\bar{u}$.

For simplicity the analysis was restricted to linear regression. The simple correlation coefficients from group 1 and group 2 are presented in Tables I and II.

Degree day is the most important single variable in the determination of sulfur dioxide concentrations. Stability and wind speed have approximately equal influence upon SO_2. As expected prior to analysis, degree day has a smaller effect on C* than upon SO_2. The effects of all three meteorological variables are of about the same magnitude upon C*. However, wind speed and stability effects upon C* seem to be slightly greater than upon SO_2. Since the data were divided according to SO_2 rankings, it is disappointing to find the correlations with SO_2 are all slightly lower in group 2, whereas the correlations with C* are about the same in both groups.

The correlations of air quality with wind speed are slightly greater than

Table II—Correlation Coefficients, Group 2

	DD	$\bar{s}$	$\bar{u}$	$1/\bar{u}$
SO_2	0.59	0.44	−0.42	0.16
DD	—	0.10	−0.07	−0.13
$\bar{s}$	—	—	−0.59	0.51
$\bar{u}$	—	—	—	−0.80
C*	0.51	0.59	−0.51	0.32

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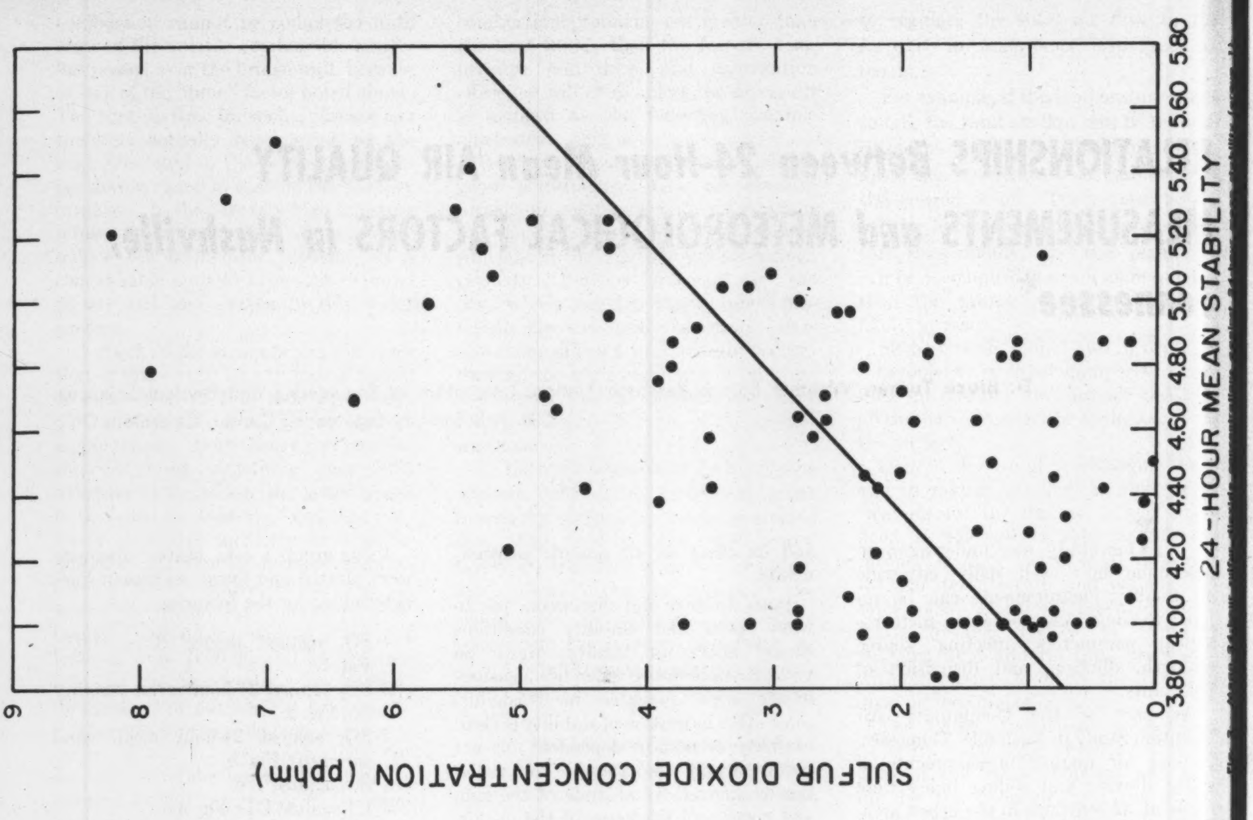
* Presented at the 54th Annual Meeting of APCA, Commodore Hotel, June 11–15, 1961, New York, New York.



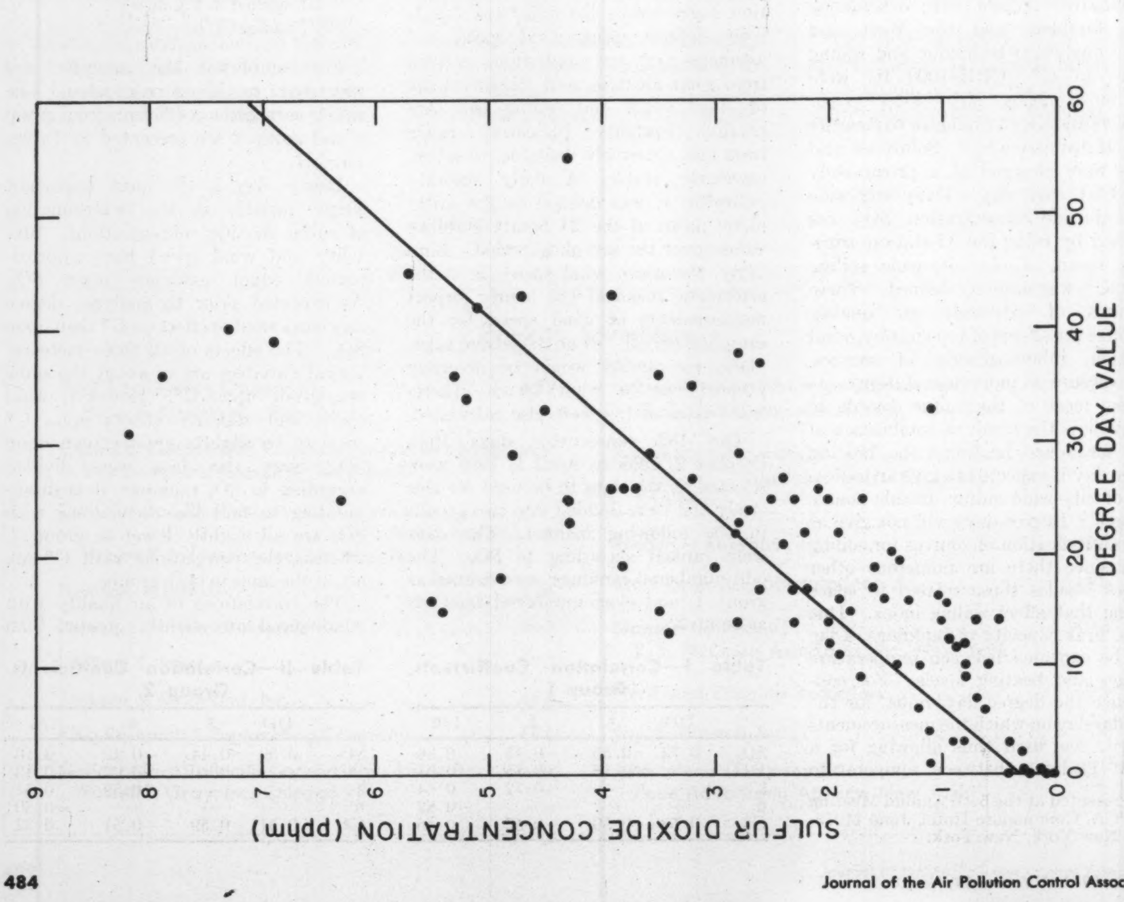


Fig. 1. Mean 24-hour sulfur dioxide concentrations against degree day values (group 1).

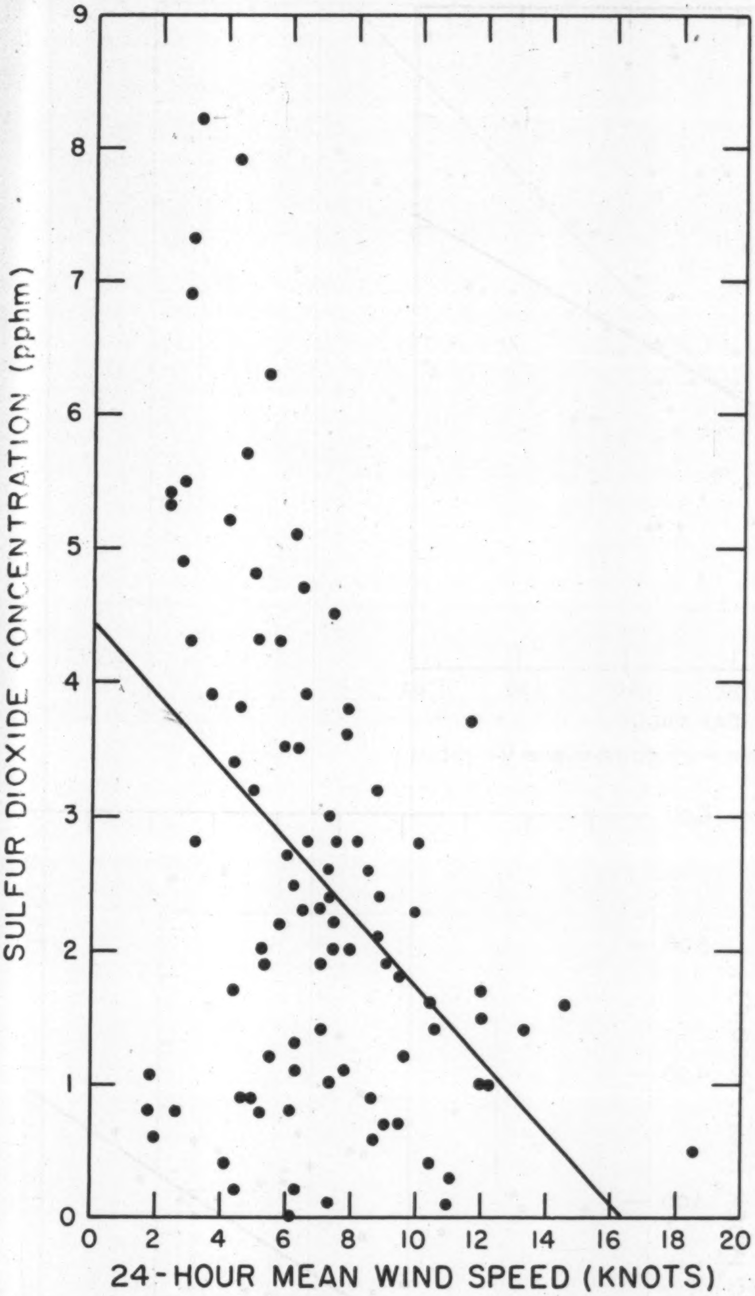


Fig. 3. Mean 24-hour sulfur dioxide concentrations against 24-hour mean wind speed (group 1).

Table III

	Correlation Index	Percent of Variance Explained	Standard Error of Estimate
Group 2, Test Data			
Calculated SO_2 against observed	0.69	48%	1.26 pphm
Calculated C* against observed	0.75	56%	0.76 C*
Group 1, Developmental Data			
Calculated SO_2 against observed	0.85	72%	0.99 pphm
Calculated C* against observed	0.77	59%	0.73 C*

those with the reciprocal of wind speed. This is at least partly due to slight dispersion associated with light winds and greater dispersion with strong winds. This is also affected by 24-hour averaging of quantities having dissimilar diurnal variations.

It may be of interest to note here that the SO_2 and C* values were quite highly correlated. The correlation coefficient for group 1 was 0.83 and for group 2, 0.80. The following are the regression equations:

Group 1

$$SO_2 = -0.006 + 1.346\ C^*$$
$$C^* = 0.598 + 0.510\ SO_2$$

Group 2

$$SO_2 = 0.174 + 1.235\ C^*$$
$$C^* = 0.597 + 0.516\ SO_2$$

In order to determine the over-all effect of the three meteorological variables on air quality measurements, data from group 1 were used to find multiple linear regression equations. Because of its higher correlation with both air quality measurements, $\bar{u}$ was used instead of $1/\bar{u}$. The equations resulting from group 1 data follow:

$$SO_2 = -5.946 + 0.101\ DD + 1.5\ \bar{s} - 0.06\ \bar{u}$$
$$C^* = -2.8810 + 0.0460\ DD + 0.97\ \bar{s} - 0.071\ \bar{u}$$

These equations were then solved using meteorological data for group 2 yielding calculated values of SO_2 and calculated values of C*. This was also done for group 1 data from which the equations were derived. The calculated values were then compared with the city-wide values. These are shown for group 2, the test data, in Figs. 7 and 8. The correlation indices, the percent of variance explained by the three meteorological variables, and the standard errors of estimate are given in Table III.

The net effects of the three meteorological variables explain about half of the variance of both SO_2 and C*. Since the correlation indices are nearly the same in both groups for C*, it appears that 91 cases are enough to attain a stable relationship. However, the case is quite different with the correlation indices for SO_2, consistent with the previous findings with regard to the simple correlation coefficients. A stable relationship has not been found relating the meteorological parameters with SO_2. A possible explanation for this is that SO_2 is emitted predominantly from elevated sources, whereas the particulate matter that affects soiling index comes from ground level as well as elevated sources. This should cause meteorological parameters to be more complexly related to sulfur dioxide concentrations than to soiling indices.

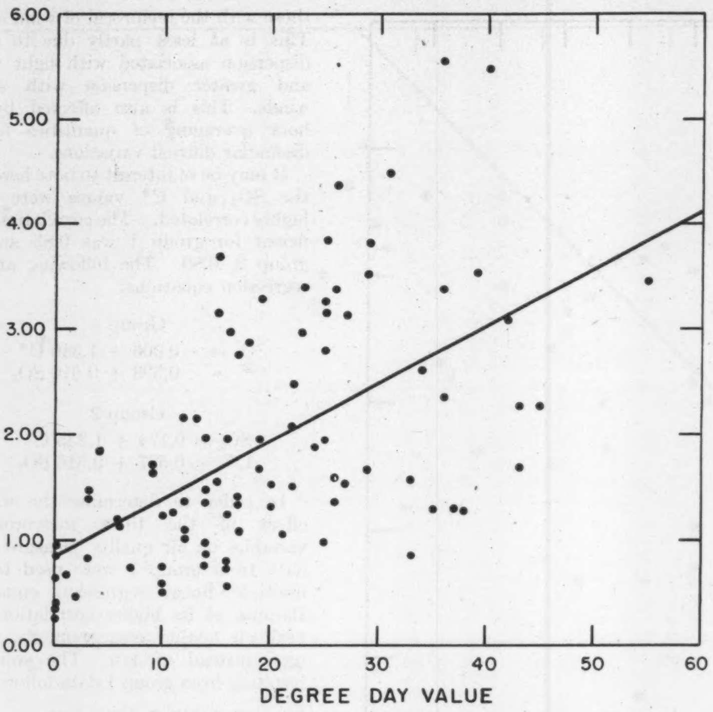


Fig. 4. Mean 24-hour soiling indices against degree day values (group 1).

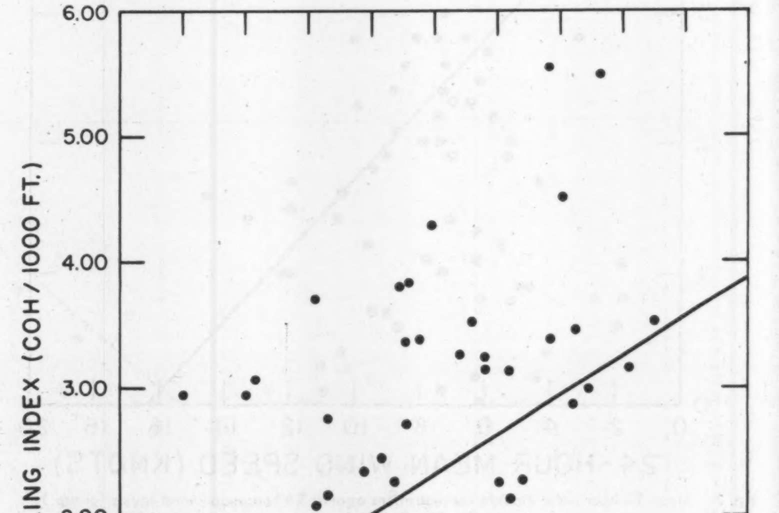


Fig. 5. Mean 24-hour soiling indices against 24-hour mean stability (group 1).

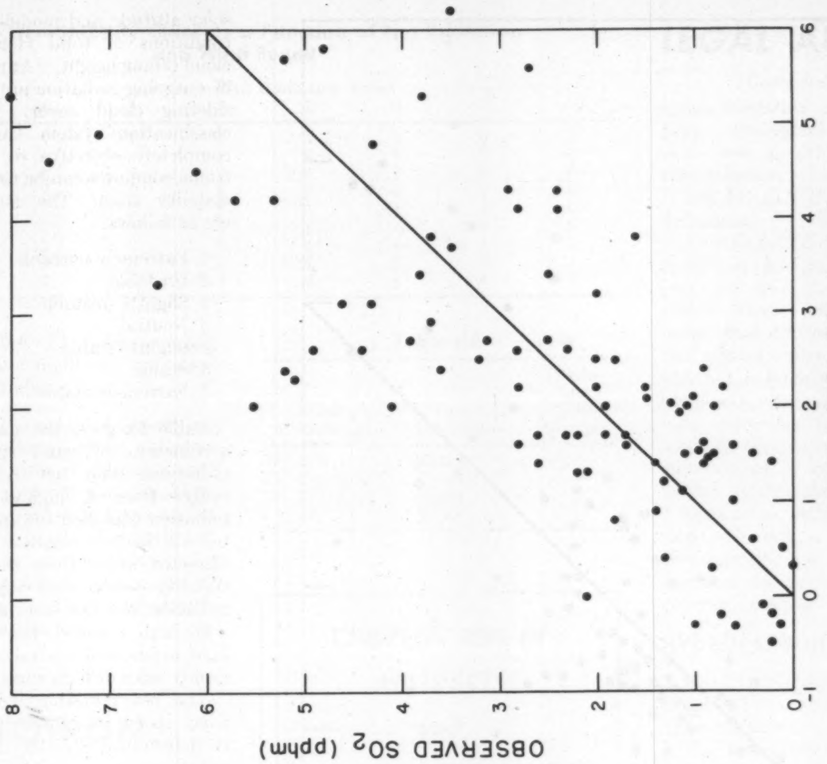


Fig. 7. Observed mean 24-hour SO$_2$ against calculated mean 24-hour SO$_2$ from regression equation (group 2).

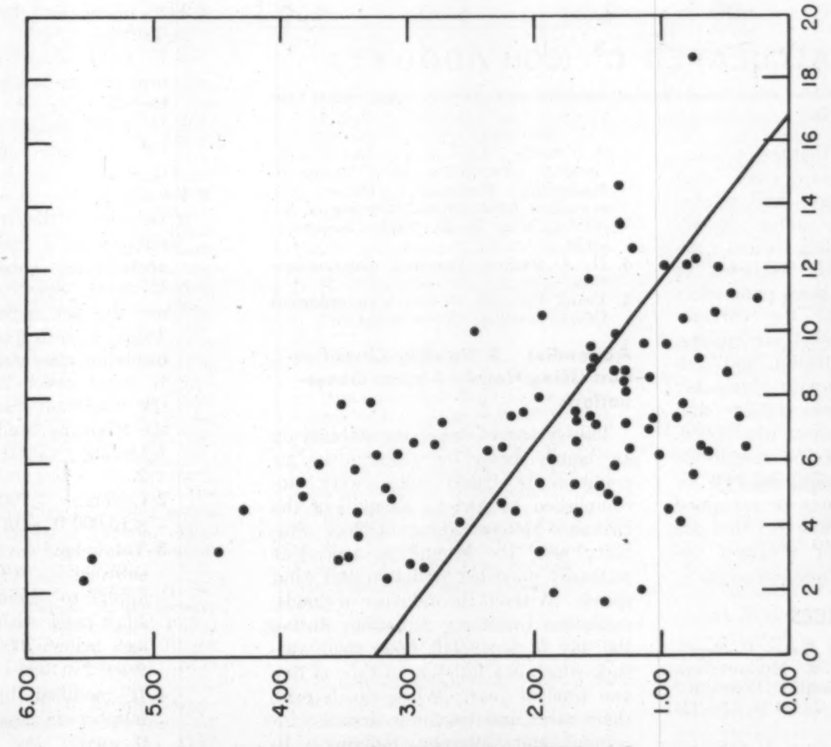


Fig. 6. Mean 24-hour soiling indices against 24-hour mean wind speed (group 1).

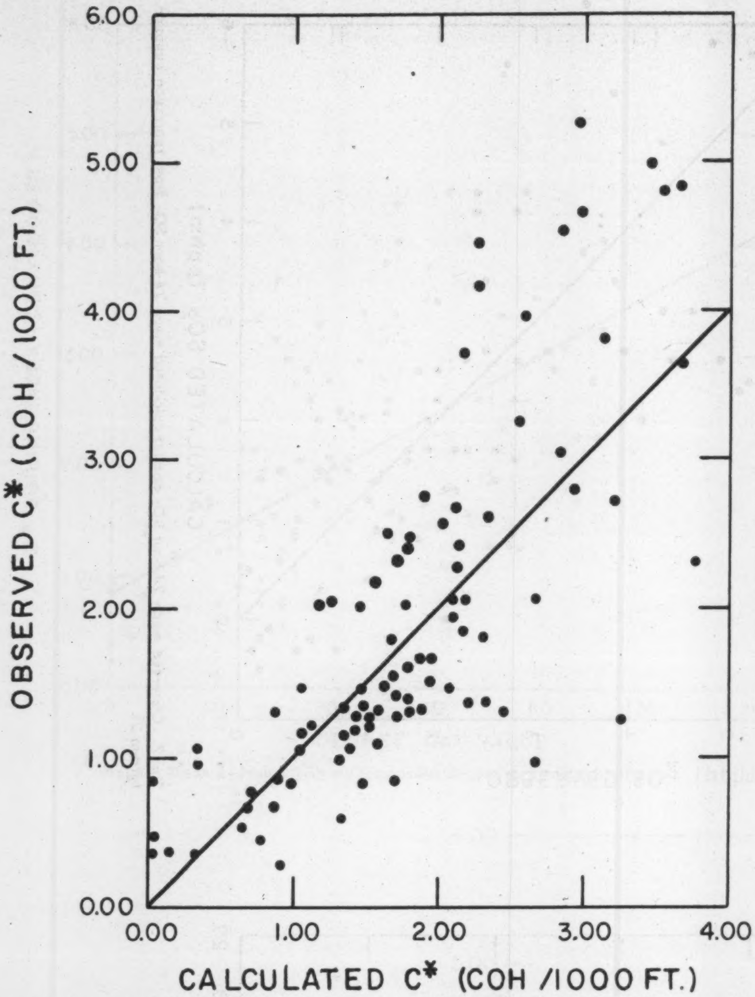


Fig. 8. Observed mean 24-hour soiling indices against calculated mean 24-hour soiling indices from regression equation (group 2).

It may be concluded that the meteorological variables of temperature, wind speed, and stability are well related to 24-hour city-wide sulfur dioxide concentrations and soiling indices. Although the analysis is restricted to linear regressions, the three parameters explain about half of the variance of these two measures of air quality. Sulfur dioxide concentration and soiling index vary directly with degree day value and 24-hour mean stability and inversely with 24-hour mean wind speed. This study illustrates the magnitude of the variability of daily city-wide air quality levels which may be explained by meteorological parameters that are routinely measured or obtained objectively from routine measurements.

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Appendix: A Stability Classification Using Hourly Airport Observations

This system of classifying stability on an hourly basis for research in air pollution is based upon work accomplished by Dr. F. Pasquill of the British Meteorological Office. Stability near the ground is dependent primarily upon net radiation and wind speed. Without the influence of clouds, insolation (incoming radiation) during the day is dependent upon solar altitude which is a function of time of day and time of year. When clouds exist their cover and thickness decrease incoming and outgoing radiation. In this system insolation is estimated by solar altitude and modified for existing conditions of total cloud cover and cloud ceiling height. At night estimates of outgoing radiation are made by considering cloud cover. This stability classification system has been made completely objective so that an electronic computer can be used to compute stability class. The stability classes are as follows:

1 Extremely unstable
2 Unstable
3 Slightly unstable
4 Neutral
5 Slightly stable
6 Stable
7 Extremely stable

Table IA gives the stability class as a function of wind speed and net radiation. The net radiation index ranges from 4, highest positive net radiation (directed toward the ground), to −2, highest negative net radiation (directed away from the earth). Instability occurs with high positive net radiation and low wind speed, stability with high negative net radiation and light winds, and neutral conditions with cloudy skies or high wind speeds.

The net radiation index used with wind speed to obtain stability class is determined by the following procedure:

1 If the total cloud cover is 10/10 and the ceiling is less than 7000 feet, use net radiation index equal to 0 (whether day or night).
2 For nighttime (between sunset and sunrise):
  a If total cloud cover $\leq 4/10$, use net radiation index equal to −2.
  b If total cloud cover $>4/10$, use net radiation index equal to −1.
3 For daytime:
  a Determine the insolation class number as a function of solar altitude from Table IIA.
  b If total cloud cover $\leq 5/10$, use the net radiation index in Table I corresponding to the insolation class number.
  c If cloud cover $>5/10$, modify the insolation class number for the following conditions:
    1 Ceiling <7000 ft, subtract 2.
    2 Ceiling ≥ 7000 ft but $<16{,}000$ ft, subtract 1.
    3 Total cloud cover equal 10/10, subtract 1. (This will only apply to ceilings ≥ 7000 ft since cases with 10/10 coverage below 7000 ft are considered in item 1 above.)
    4 If modified insolation class number is less than 1, let it equal 1.
    5 Use the net radiation index

Table IA—Stability Class as a Function of Net Radiation and Wind Speed

Wind Speed (kts)	Net Radiation Index 4	3	2	1	0	−1	−2
0, 1	1	1	2	3	4	6	7
2, 3	1	2	2	3	4	6	7
4, 5	1	2	3	4	4	5	6
6	2	2	3	4	4	5	6
7	2	2	3	4	4	4	5
8, 9	2	3	3	4	4	4	5
10	3	3	4	4	4	4	5
11	3	3	4	4	4	4	4
≥12	3	4	4	4	4	4	4

in Table IA corresponding to the modified insolation class number.

This objective system of classifying stability from estimates of net radiation as a function of time of day and time of year and hourly airport measurements of wind speed, total amount of cloud, and ceiling height is expected to be of some use in air pollution studies where some better measurement of stability such as vertical temperature difference is not available.

Table IIA

Solar Altitude (a)	Insolation	Insolation Class Number
$60° < a$	Strong	4
$35° < a \leq 60°$	Moderate	3
$15° < a \leq 35°$	Slight	2
$a \leq 15°$	Weak	1

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29. V. L. Miller, D. F. Allmendinger, F. Johnson, and D. Polley, "Lime Papers and Indicator Plants in Fluorine Air Pollution Investigations," *Agr. Food Chem.*, 1: 525 (1953).
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LEGAL ABSTRACTS

(*Continued from p. 478*)

recommendation of an expert in the field. Defendant also testified that there was no other suitable place for this operation.

TRIAL COURT: Jury verdict for defendant.

APPELLATE COURT: Held that it was all right to send the case to the jury on the question of negligence rather than nuisance. The court noted that the area had long been a coal mining center and that the business was not a nuisance per se. Likewise, the court observed that the operators were extremely careful and employed modern equipment to keep the dust emission at a minimum. The jury verdict for defendant was affirmed.

Defendant contended that its operation was not a nuisance and that therefore it could not be liable for damages unless it was negligent. No other defense was mentioned.

HYDROCARBON ANALYZER

(*Continued from p. 469*)

ally, the IR may be dropped in favor of hydrogen flame.

The hydrocarbon analyzer is ideally suited to instrumentation for auto exhaust inspection, providing simplicity and low cost, high speed of response, inherent high sensitivity, and discrimination against other exhaust components.

In general, the hydrocarbon analyzer will apply to the determination of total hydrocarbons in inert or inorganic gases such as He, A, N_2, H_2, and air. Determinations of carbon content in concentrations from 0.1 ppm to 25% are possible with excellent discrimination against water, CO, CO_2, and other inorganic gases. The instrument gives equivalent sensitivity for various hydrocarbons, thus it is not selective for mixtures of organic compounds.

REFERENCE

1. J. C. Sternberg, Wm. S. Gallaway, and D. T. L. Jones, "The Mechanism of Response of Flame Ionization Detectors." ISA Proceedings 1961 International Gas Chromatography Symposium.

CLEAN AIR CONFERENCE

A Clean Air Conference, sponsored jointly by the New South Wales Department of Public Health and the University of New South Wales, will be held in Sydney, Australia, February 19 to 21, 1962. Object is to give opportunity for technical discussion of the problems of air pollution and to supply information on proposed legislation.

SECRETARY RIBICOFF WARNS AUTO INDUSTRY THAT AP CONTROL DEVICES MUST BE PROVIDED

Secretary of Health, Education, and Welfare Abraham Ribicoff has served notice that the automobile industry must pledge by January to provide blow-by control devices as standard equipment on 1964 cars, or he will ask for legislation to require them.

Such devices reduce air pollution from exhaust fumes.

Mr. Ribicoff said he preferred that the effort be carried out voluntarily by the manufacturers, but that he will move in January to seek legislation if the industry has not announced a voluntary agreement.

The Secretary, representatives of the Automobile Manufacturers Association, Inc., Detroit, and the engineering representatives of the major auto manufacturers met with newsmen following a discussion of the problem.

Blow-by gas is just what the name implies—unburned or partially burned hydrocarbons which blow by the cylinders of an automobile engine.

Such engines have a draft tube through which these gases escape into the atmosphere. The device under study captures the vapors and returns them through the combustion chamber.

One such device has been standard on all 1961 cars offered for sale in California. It is manufactured by the AC Spark Plug Division of General Motors and costs a car buyer slightly more than $5.

AC Spark Plug has submitted the device to air pollution authorities in California, suggesting it may solve most of the smog problems which arise from unburned hydrocarbons.

While standard in California, the device may be obtained on cars anywhere by special order.

Tests Delay Adoption

Mr. Ribicoff explained that he had been told the industry is in the process of testing blow-by control devices, and that it will take until next April to finish the testing.

Because of the time required in manufacturing and model production of automobiles, Mr. Ribicoff said the testing schedule seemed to eliminate the possibility of having the devices on 1963 models as standard equipment.

He added that in any event he wanted 1964 cars, which go into production in the fall of 1963, equipped with the devices.

Mr. Ribicoff said he understood the cost of the devices when mass-produced and installed at the factories would be something like $4 or $5.

Ralph H. Isbrandt, vice president of automotive engineering research for American Motors Corporation, Detroit, said the cost of such devices as optional equipment in California on 1961 models is $4.25 to $6.

California is the only state which now has legislation to control motor vehicle pollution.

Los Angeles has long had a well-publicized problem with smog—a mixture of fog, exhaust fumes, and other pollutants.

UNIVERSAL PROCESSES DELIVERS MUFFLER TO CALIFORNIA BOARD

Universal Oxidation Processes, Inc. has delivered one of its Purzaust catalytic mufflers to the California Motor Vehicle Pollution Control Board, according to M. P. Venema, board chairman of the parent organization, Universal Oil Products Company, Des Plaines, Illinois.

In his announcement, Mr. Venema stated, "this is another step in our program to make Purzaust available to the California authorities for testing and final certification." Last February UOP submitted the first application, containing the required technical data, to be received by the Board.

Mr. Venema also announced that the installation of equipment for the volume production of Purzaust units has been completed. These facilities, recently installed at the Waskom, Texas plant of a subsidiary company, will go into full-scale operation immediately upon certification of Purzaust for installation of automobiles in California.

Important to the Purzaust program is the recent opening of Los Angeles laboratories by Universal Oxidation for continued research and testing of the catalytic muffler.

COMMITTEE APPROVED

The Nominating Committee for the election of a president and six members of the Board of Directors has been approved by the Board.

The members are as follows: Chairman Vern MacKenzie, U. S. Public Health Service, Washington, D. C.; Dr. C. A. Bishop, U. S. Steel Corporation, Pittsburgh, Pa.; L. B. Hitchcock, Lauren B. Hitchcock Associates, New York, New York; Harry M. Pier, Basking Ridge, New Jersey; F. R. Rehm, Department of Smoke Regulation, Milwaukee, Wisconsin; V. H. Sussman, Department of Health, Harrisburg, Pennsylvania.

PLANNING TASK FORCE TO FORMULATE PROGRAM

Responding to a request initiated by the President's Special Assistant for Science and Technology, Dr. Jerome Wiesner, to recommend goals and outline a national plan for the atmospheric sciences over the next 10 years, a Planning Task Force of 150 scientists is convening in the national headquarters of the American Meteorological Society. The "Planning Task Force" is responsible to the National Academy of Sciences through its Committee on the Atmospheric Sciences.

Director of the Academy's Planning Task Force is Professor Sverre Petterssen, chairman of the Department of the Geophysical Sciences of The University of Chicago and immediate past president of the American Meteorological Society.

Guidance for Government

One of the aims of the 10-year plan for the atmospheric sciences will be to guide the U. S. government to insure an adequate and balanced advance on a broad front. The stability provided by such long-range planning will result in sounder use of government funds. The setting of challenging goals will attract young talents to the nation's research effort.

To outline U. S. needs for manpower, funds, and facilities, six separate conferences were held on the subjects of Biometeorology, Atmospheric Physics and Chemistry, Atmospheric Dynamics, Atmospheric Structures and Circulations, Engineering Meteorology, and New Technology. The development of an integrated plan will follow these discussions.

Welcome New Members

INDIVIDUAL MEMBERSHIPS

Carkeek, Charles R.
Pasadena, California

Ferguson, Samuel A.
San Mateo, California

Gravely, David A.
Louisville, Kentucky

Pattison, John N.
San Bernardino, California

Rehm, J. G.
Chicago, Illinois

Stoltz, Jr., Emil M.
Joliet, Illinois

Waddington, John
Kinlochleven, Argyll, Scotland

COMPANY MEMBERSHIPS (Local)

Fire Engineers Incorporated
Minneapolis, Minnesota

Paromal Precision Controls, Inc.
Freeport, New York

SUSTAINING MEMBERSHIP

Texaco Inc.
Beacon, New York

PITTSBURGH WORKS OF J&L BOAST NEW AIR CLEANERS ON OPEN HEARTH

The switch has been thrown activating the big new air cleaners on the No. 4 open hearth steelmaking shop at the Pittsburgh Works of Jones and Laughlin Steel Corporation.

This milestone in Pittsburgh's drive for cleaner air was witnessed by officials who have been leaders in the drive over the years.

Walter H. Lewis, Works Manager, demonstrated the new equipment. He stated that the official start-up of the new facilities climaxed a five-year experimental and construction program.

"The installation, which cost approximately $10 million for the 11-furnace shop, includes giant air filters (electrostatic precipitators) and waste heat boilers," Mr. Lewis continued.

"The precipitators are designed, when break-in periods have been completed, to reduce the emission of dust into the atmosphere by almost 99%. The new units are engineered for a greater efficiency than is required by the Allegheny County Air Pollution Control code."

Charles M. Beeghly, J&L President, indicated that the major importance of this new air cleaning achievement lies in the promise it holds for the great cities of America. "If Pittsburgh is to continue its Renaissance, we must do more than build new parks and buildings. We believe that our Pittsburgh Works, situated as it is in the heart of the city, is and must be a leader in developing techniques to minimize air pollution. This project cost as much as the Fort Pitt Bridge. The money spent on air pollution control devices by J&L in Pittsburgh and Cleveland in the past three years is equal to the cost of the Fort Pitt Tunnels.

Major Problem Corrected

"While we have corrected the most important major problem, unfortunately other lesser air pollution problems still exist here, and elsewhere in the community. Some of our problems need further research, and that work is under way. Other problem areas will be corrected as rapidly as scheduled replacement facilities can be made available."

Herbert J. Dunsmore, Chief, Bureau of Air Pollution Control of the Allegheny County Health Department, said:

"Jones & Laughlin is to be congratulated for making this important contribution to the control of air pollution in Pittsburgh. Needless to say, I am most pleased that these belching smoke stacks have been tamed.

J&L Six Months Ahead of Time

"The people of Pittsburgh should be encouraged, as we are, by J&L's accomplishment, which comes six months ahead of the schedule adopted for control of air pollution by steel firms.

"J&L's new precipitators are an excellent example of the results that can be obtained in the drive for cleaner air for the people of Pittsburgh through the joint action of government and the steel industry with its technical and administrative know-how."

Fred C. Foy, Chairman of the Board, Koppers Company, Inc., the firm that built the giant air-cleaning electrostatic precipitators for J&L, said:

"Koppers is pleased to have worked closely with Jones and Laughlin on this gas cleaning installation, and we commend them on a valuable contribution to Pittsburgh's progress. Our company has enjoyed a pleasant relationship with Jones and Laughlin through the years, and we are glad to have cooperated with them on this project which will aid our city's advancement."

J&L also has made large strides in the control of air pollution in other departments of the Pittsburgh Works and at its Cleveland Works and Aliquippa Works.

This new air filter program at the Pittsburgh Works also includes new waste heat boilers that will materially reduce fly ash problems from boilers on the north side of the river. Three new batteries of coke ovens installed since 1959 have also been equipped with the best control devices available.

Facilities To Be Equipped With Latest

At Cleveland, all iron and steelmaking facilities will be equipped with the most modern devices for smoke control later this year upon completion of what will be the world's largest basic oxygen steelmaking furnaces and the accompanying electrostatic precipitators for the new furnaces and the remaining open hearths.

At the Aliquippa Works, the basic oxygen furnaces have been equipped with electrostatic precipitators, and orifice scrubbers are being installed on the Works' blast furnaces. The new sinter plant, as well as other new units, has been equipped with the most modern smoke controls available.

The first of the precipitators at the Pittsburgh Works—an experimental unit—was placed in operation in April 1959. Data from this unit then were used in the design of the remaining units.

CLEANER AIR WEEK TO BE CELEBRATED OCTOBER 22–28

For the seven days beginning October 22 to 28, millions of Americans will have their attention directed toward a National problem—air pollution—through observance of the Nation's 13th Annual Cleaner Air Week.

Sponsored by the Air Pollution Control Association, Pittsburgh, Pennsylvania, Cleaner Air Week is now an established autumn fixture in the National Promotional Calendar.

Cleaner Air Week is based on the one general area of agreement about pollution control—it's everybody's business. Whether we make it or take it, all of us have a stake in air pollution—and its control. Alone, each of us is helpless. It is teamwork that will clinch the victory for cleaner air.

One of the Association's principal objectives in sponsoring Cleaner Air Week 13 years ago was to promote the public understanding and co-operation necessary in the community-wide approach to pollution control.

Cleaner Air Week is directed by APCA's Cleaner Air Week Committee from the Cincinnati office of Chairman Charles Howison. Local Cleaner Air Week Committees in scores of cities across the nation are the operating units of the campaign. The National Committee has prepared a booklet wherein procedures are suggested for organizing local CAW committees to make maximum use of the National campaign at the community level.

AMENDMENTS ADOPTED

Three proposed amendments to the By-Laws were submitted to a membership vote and each one was adopted. They are as follows: (1) Power of Executive Committee, Article IX, Officers, Section 1, Paragraph 4; (2) Proposed By-Law Amendment for Dissolution and Disposal of Funds as Required by Exempt Organizations Branch of the Internal Revenue Department, Article IV, Section 2, Association Assets; (3) Proposed By-Law Amendment concerning the clarification of succession of Presidency, as outlined in statement attached to letter dated July 14, 1961.

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$2.00 @ for Non-Members overseas.

NEWS FROM THE CONTROL DISTRICTS

Los Angeles

An improved nation-wide attack on community air pollution problems was urged in Chicago by the two delegates attending the 26th Annual Conference on the National Association of County Officials.

Stating that "fresh, clean air is an American national resource which must be conserved and protected," the Association adopted several new policies for inclusion in its "American County platform." One of these urges the automobile industry to install crankcase fume control devices on all new vehicles manufactured for sale in the United States.

The new policy statement on motor vehicle contamination states that "pollution emission from motor vehicles has become a significant national problem" and that "responsibility for solving this problem is a burden on the vehicle manufacturers." It asks the automobile industry to install inexpensive blow-by control devices on all new vehicles as standard equipment. At present these devices are installed on new vehicles sold in California and then only as optional equipment.

Urge AP Conference

The Association also urged President John F. Kennedy to convene a White House conference of air pollution, and asked the Congress to adopt legislation establishing a Federal air pollution research and assistance program "without specific limitations on annual appropriations or the program duration." The present air pollution program has been operated as a temporary program with a restricted life and a stationary limit on annual appropriations.

Air Pollution Control Officer Smith Griswold has recommended that a simple and economical means of controlling smog-producing fumes from automobile crankcases be approved for installation on used cars throughout California.

In a report to the State Motor Vehicle Pollution Control Board, Mr. Griswold said that after more than 2.5 million miles of road testing, Los Angeles County has found that there are two systems for carrying crankcase fumes back into the intake system and both had proved effective and trouble free, that either alone eliminated 80% of the hydrocarbons from the crankcase, and both together eliminated 100%.

County Installing System

He said that the County was installing both systems on all of the 3500 cars of its fleet, and recommended that the State Motor Vehicle Pollution Control Board require the installation of either type on most of the approximately eight million vehicles in the State as sufficient to meet the control standard that has been set.

"The simpler of the two systems has an estimated cost of $1.50 and is inexpensive to install," Mr. Griswold said. He described the device as a simple tube to the carburetor air cleaner plus fittings to hold it in place.

Bay Area

The "orders, rules and regulations" of the Board of the six-county Bay Area Air Pollution Control District acquired new authority from the state legislature, when Governor Edmund G. Brown signed into law an amended section of the Health and Safety Code.

The bodies to which District regulations now will apply include "every state agency, governmental subdivision, district, public and quasi-public corporation, public agency, and public service corporation, and every town, city and county, and municipal corporation."

Many Co-operate

Board Chairman Clarissa S. McMahon pointed out, "Many of these agencies have given us their co-operation already, but the new law will enable us to achieve uniform compliance and eliminate unfair advantages."

Control Officer Benjamin Linsky also expressed his approval, "We're pleased to have the legislature reaffirm the need for all government agencies to control their own air polluting operations under the same requirement as private owners."

New York City

During the first six months of 1961, the New York City Department of Air Pollution Control established a number of enforcement records, it was announced today by Commissioner Arthur J. Benline. A record number of complaints was received; new highs were set in the issuance of violation notices and summonses, and a record amount in fine was levied.

All-Time High Received

Commissioner Benline pointed out that in June an all-time high in complaints, 2450, was received by the Department. He attributed this primarily to the extensive publicity given to air pollution control because of the 54th Annual Meeting of the Air Pollution Control Association, held here June 11 through 15. The previous one month record for complaints was set in July 1957, when 1981 were received by the Department.

PRECIPITATORS OPERATE FROM COMMON DUCT IN J&L INSTALLATION

In the new installation at the J&L Pittsburgh Works, eight electrostatic precipitators operate from a common duct to control dust from the shop. Each of the 11 furnaces has been equipped with a large waste heat boiler or heat exchanger to lower the temperature of the large quantities of gas which result from the open hearth process and which formerly carried the dust into the atmosphere. As much as 50,000 cu ft of gases at temperatures from 900 to 1200°F is discharged per minute from each furnace. This discharge of gas, with all furnaces in the shop operating, would more than fill the entire new Civic Arena in 10 minutes.

Temperature of the gases must be reduced to approximately 500°F before they can be treated in the electrostatic precipitators.

New Boilers Minimize Fly Ash

J&L's decision to install the waste heat boilers to reduce this gas temperature also will aid in controlling air pollution at the Works' steam generating facilities. Use of the new boilers at the Open Hearth will minimize the fly ash discharged from the north side boilers.

To accomplish this, a heavily insulated 18-inch steam pipe line is being installed across the Monongahela River on the J&L-owned railroad bridge. Meanwhile, a new pressure reducing station, and existing low pressure lines will be utilized.

Gases Sent Into Large Duct

After reduction in temperature, the gases then are discharged into a large main or common duct, and then into eight electrostatic precipitators. A large steam turbine-drive fan on each furnace moves the gases from the furnaces through the boilers and into the precipitators.

How Precipitators Work

The precipitators are designed to produce a positive electric charge on all the solid particles in the gases as they pass through the chamber. These positively charged particles then are attracted to negatively charged electrode plates. The particles cling to the plates until the plates are vibrated. The dust then falls into receiving hoppers, is conveyed pneumatically through pipe lines into a main storage hopper where it is thoroughly drenched with water, and is loaded into a truck or railroad car for disposition.

LETTERS TO THE EDITOR

(Continued from p. 451)

631) that the acid absorbed by the water was nitric (HNO_3). Each liter of water contained 500,000 ionized anhydrous nitric acid radicals (NO_3) hydrolyzed with water, forming the same number of HNO_3, nitric acid, molecules. This is the same hydrolyzing action that goes on in the moisture of the human lungs. This slow burning of the human lungs goes on in our cities 24 hours a day not as fast as it did in the lungs of Fred Wise and the miners in the Idarado mine, but just as surely, because when anhydrous nitric acid is inhaled, it forms nitric acid in the lungs and reacts with the alkaline blood and the lung tissue and is never exhaled. This is why industrial hygienists call it insidious—because its toxicity accumulates.

The United States Bureau of Mines, in their information circular I.C. 7222, October 1942, had this to say about oxides of nitrogen before diesel power became the panacea of the big city transit companies' problems:

"The values more recently accepted as permissible maxima of toxic gases show a definite trend toward lower values. This is particularly true of the value of nitrogen oxides.

"Although acute poisoning from toxic gases may be fatal, nevertheless the most important hygienic risk from any poisonous substance is that which results from constant and repeated exposure." (Big cities, please note.)

This report further states on page 24: "The controlling noxious gas (in diesel exhaust) is nitrogen oxides, which, under currently accepted tolerance limits, are 10 times more deadly than carbon monoxide. . . ."

It is obvious that in 1942 the Bureau of Mines considered NO_2 10 times more deadly than CO. The trend as prophesied in Bureau of Mines I.C. 7222 has been fulfilled for NO_2; its M.A.C. has now been lowered from 25 ppm to 5 ppm for an eight-hour exposure. ("A Bible of Safety Information on the Dangerous Properties of Industrial Materials," by N. Irving Sax, Leonard J. Goldwater, William Harris, John Harley, Joseph Fitzgerald, Milton S. Dunn, published 1957, Congress Library card number 57-13170, page 950.) This is in keeping with the suggestions made at the Transactions of the 16th Annual Meeting American Conference of Government Industrial Hygienists, Chicago, Illinois, April 24–27, 1954, to wit:

"Nitrogen oxides should be revised downward from the past value of 25 ppm to 5 ppm on the basis of the work reported by the Army Chemical Center performed in 1951. Errors in appraising the true toxicity of nitrogen oxides appear to have occurred in the past because of failure to standardize on the most toxic component of nitrogen oxides, nitrogen dioxide. Nitrogen dioxide now appears to be a major contributor to the toxicity under most conditions where these gases are produced. The problem of setting the limits for this group of gases is a most difficult one because of the variation in amount, and types of nitrogen oxide gases produced. The M.A.C. Committee is currently submitting information urging a limit lowered to 5 ppm from the former value of 25 ppm for nitrogen dioxide with the further suggestion that future values be assigned to specific nitrogen oxides."

Workmen and the public take a beating from breathing untreated nitrogen dioxide from diesel exhaust. For example, a workman who, according to Dr. Good, died from pneumonia induced by long exposure to diesel exhaust, did not rate workmen's compensation by the Colorado Industrial Commission. Dr. Good states that pneumonia caused by diesel fumes did not respond to antibiotic drugs. In London, where diesel buses are used almost exclusively in city transit service, the doctors apparently know nothing about the NO_2 content of diesel exhaust, but they do recognize something in London smog that creates the same kind of pneumonia that Dr. Good found in treating the Idarado miners. I quote:

"Their lung ailments become chronic and now they could not be eradicated completely even by the latest antibiotic drugs." (*Pageant*, April 1955, page 25.)

If the past is any criterion, workmen in concentrated diesel fumes and citizens using bus terminals will not get compensation if they die at home or in the hospital, even though it is the result of pneumonia caused by NO_2. This, because the average doctor is not familiar with the toxicity of NO_2 produced by diesel exhaust. I quote from the book *The Analytical Chemistry of Industrial Poisons, Hazards and Solvents*, by Morris B. Jacobs, Ph.D.:

"The fumes of the nitrogen oxides are extremely dangerous because of their insidious character. The bad feature of this type of poisoning is that little warning is given to the worker, for the oxides of nitrogen fail to set up defense respiratory reflexes. Thus a worker may inhale quantities of these gases that will affect him seriously and even cause death, without knowing it. Cases have been recorded where the workman felt entirely well throughout the working day after the inhalation of these fumes, only to die the following day because of pulmonary edema. Symptoms after exposure are restlessness, with a dry cough and shortness of breath. These symptoms increase and are accompanied by a frothy sputum

(Continued on p. 494)

GERMAN SCIENTISTS VISIT APCA

SUMMER VISITORS—APCA Headquarters had two distinguished visitors from Germany during the summer. Dr. Ernst Abrahamczik *(left)* and Bernhard Wurzschmitt *(right)* discuss air pollution problems with Jack Largarias *(left center)* of Koppers Company, Pittsburgh, and Arnold Arch, Executive Secretary. Dr. Abrahamczik and Mr. Wurzschmitt were both present at the 54th Annual Meeting in New York.

LETTERS TO THE EDITOR

(Continued from p. 493)

tinged with blood. Death may follow from pulmonary edema, even after several days."

The subject of NO poisoning is treated in still another book, *Industrial Toxicology*, by Lawrence T. Fairhall. Says he, regarding nitrogen dioxide:

"In whatever molecular form nitrogen dioxide is inhaled, it is at once changed to that corresponding to body temperature. At 40°C, approximately 30% of the dioxide is in the form of NO_2 and 70% is N_2O_4. . . .Several hours after exposure, difficulty in breathing is noted and the patient is 'drowned' in his own exudate. The lungs become markedly edematous, death may occur within 24 hours or be delayed for several days (3). Because of its insidious action it is necessary that anyone who has inhaled a considerable amount of this gas should be removed at once to a hospital for immediate treatment. Fleming (4), in discussing the treatment which can be used during the 'symptom free' interval to prevent development of serious pulmonary edema, reiterates that these patients are suffering from a lack of oxygen, and if this deficiency is supplied, circulation will be maintained and no other medication will be needed. The patient surviving the initial pulmonary edema may develop pneumonia, bronchiectasis, or emphysema as sequelae. Methemoglobinemia may also occur."

Note here that Fairhall states that no other medication will be needed. This again shows, as Dr. Good, who treated the Idarado miners, stated, that antibiotics have no medical value in NO_2 poisoning, and also confirms the findings of the London doctors treating smog victims.

These facts should establish in the mind of a thinking man that NO_2 is not only toxic but it is *insidious*. The General Motors report shows that diesel engines put out up to 996 ppm of NO_2. The U. S. Bureau of Mines R.I. Report, 4032, January 1947, confirms this in Table II on composition of diesel exhaust gas. Therefore, increasing the number of diesel buses in cities will inevitably increase the toxicity of city atmosphere.

From all of the above, it should be crystal clear that it is the exhaust from diesel buses and the piston blow-by from the diesel bus that are contaminating our city air and that the blow-by and the exhaust of gasoline engines contain no toxic anhydrous nitric acid. Carbon monoxide does not form nitric acid in water, but the anhydrous nitric acid in diesel exhaust does so, both in water and in the lungs. I would be glad to demonstrate this test to you or any of your technicians, or to Senator Maurine B. Neuberger.

If you would go down in history as the man who emancipated our cities from toxic smog, admonish the Congress to pass legislation requiring diesel exhaust in our cities to be de-ionized and to detoxify the 954 ppm of toxic oxides of nitrogen that General Motors admits is in the exhaust of a 200 hp two-cycle diesel engine.

Piston blow-by is only another figment of General Motors engineers' imagination in regard to the cause of toxic smog, and will become one more "wolf, wolf," as the cause of smog, along with olefins (Cm H_2m) (gasoline vapor issuing into city air from oil tanks being filled with gasoline).

Ozone from auto exhaust, which erodes rubber and causes it to deteriorate (the catch there was that ozone could not be found in auto exhaust unless oxides of nitrogen from diesel exhaust were first put through the carburetor)—trash burners—and now, piston blow-by—all of these have been publicized in order to distract attention from the real cause of toxicity of city smog: the diesel bus.

The people in the cities of our nation are now in the same unhealthy position as were the Idarado miners who were working in the anhydrous nitric acid fumes of four General Motors diesel engines; except that in the cities there are now untold thousands of these same diesel engines contaminating the city air with nitric acid.

When the Idarado miners came to Dr. Good, he told me, he asked them: "Do you want to live?" "Then get out of those diesel fumes in that mine!" From the A.P.C.D. Los Angeles report enclosed you will note that Los Angeles doctors are telling the people of Los Angeles the same thing, and they too, by the thousands, are taking the doctor's advice. Unfortunately, there are many who can't get out.

If the doctors were running our health program instead of General Motors on the 1951 precepts of the U. S. Bureau of Mines that there are no harmful parts in General Motors diesel exhaust, it would be on the 1942 teachings of the U. S. Bureau of Mines that the oxides of nitrogen are now 20 times more toxic than carbon monoxide and their toxicity is cumulative. People could then live in cities, because doctors would force General Motors to deionize and detoxify all of the exhaust of the diesel buses which they sold in our U. S. cities on the U. S. Bureau of Mines 1951 basis it was not toxic.

This is a blow-by-blow description of what causes toxic air and smog in our cities, and paradoxically but truly, blow-by has nothing to do with it except to a gullible academic.

Very truly yours
JOSEPH P. RUTH
Denver, Colorado

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REPORT DESCRIBES CONVEYING SYSTEM

A four-page technical report describes how a pneumatic conveying system eliminates an air pollution problem at a chemical company plant located in San Francisco. Available from Fuller Company, Catasauqua, Pennsylvania, the new report details the changeover from an open-type conveyor to an enclosed pneumatic system in the handling of borax ore at Stauffer Chemical Co.

The report describes how a Fuller Airveyor (Trademark of Fuller Company) system provides automatic delivery of material from rail car through a cyclone separator-filter to a 20,000-ton capacity storage area. The system is designed to permit alternate delivery to a reclaiming weigh-hopper, either from rail car or storage.

Two photographs show the filter-separator and the five-inch pneumatic conveying line.

For copies of Fuller Fact File ER-28-1, "Dust-Tight Handling System Averts Community-Relations Threat," write to Fuller Company, Catasauqua, Pennsylvania.

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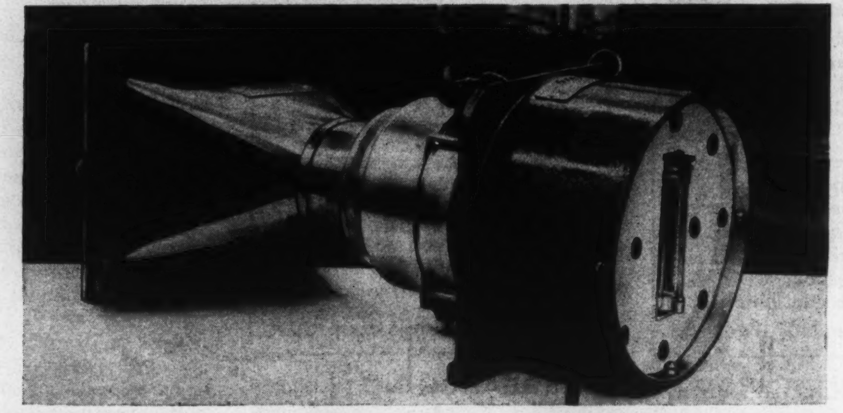

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This is the same air sampler originally developed by the New York Office of the Atomic Energy Commission. Weighs only 10 pounds. Fully portable. Stands up under heaviest usage. Yet, it does in 10 minutes what formerly took 36 hours.

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AIR POLLUTION SOLUTIONS

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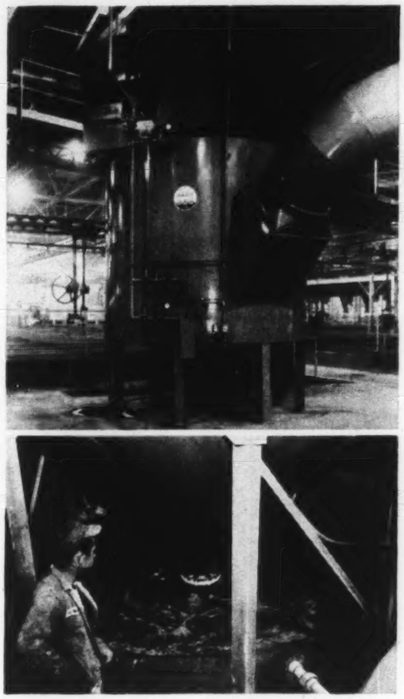

Top: 30,000 cfm Hydro-Filter similar to this one maintains above 95% efficiency. Handles dust and fume load from plant's dryers, cooler and ammoniator.

Bottom: Water is recirculated through collector from this 2500 gallon tank.

The Case of the Friendly Fertilizer Plant

Problem

With an annual output of 30,000 tons of mixed chemical fertilizer in ten different grades, a large producer was not winning any good-neighbor awards. The phone calls were mounting and the in-plant dust problem was on the increase when management installed a No. 30 Hydro-Filter wet-type dust collector.

Solution

Exhaust gases from the plant's dryer (10,200 cfm at 240°F), cooler (12,500 cfm at 180°F) and ammoniator (6580 cfm at 100°F) were routed through the 30,000 cfm Hydro-Filter. Collected contaminants are drained off to a 2500 gal. sludge tank from which water is recirculated to the collector. Fresh water is added to the collecting system only to compensate for that bled to the ammoniator.

Results

Except for an occasional flushing of the marble bed* with a garden hose and routine lubrication of fan and pump, no maintenance of the unit is required. Dust removal efficiency of the Hydro-Filter over the past two years has been maintained at above 95%...on dust loads averaging one grain per cubic foot. The phone calls have stopped. Neighborhood and employee relations are at a *friendly* new high. Equipment investment? . . . Less than $15,000.

Want more details? Write for the complete case history of this installation.

Tired of Dust Collector Maintenance?

HYDRO-FILTER CLEANS ITSELF

Air, water and glass spheres do the work in Hydro-Filter. There are no moving parts in the collection area. No baffles; nothing to load up and no "dead" areas to make cleaning a chore and efficiency a *myth*. It is designed to operate on dusts, mists, fumes, and vapors and can be equipped for recirculation of the liquid scrubbing medium.

Because of its simple, unique design, Hydro-Filter will maintain a constant high level of efficiency over wide variations in volume of air and heavy dust loads. If you're tired of dust collector maintenance . . .

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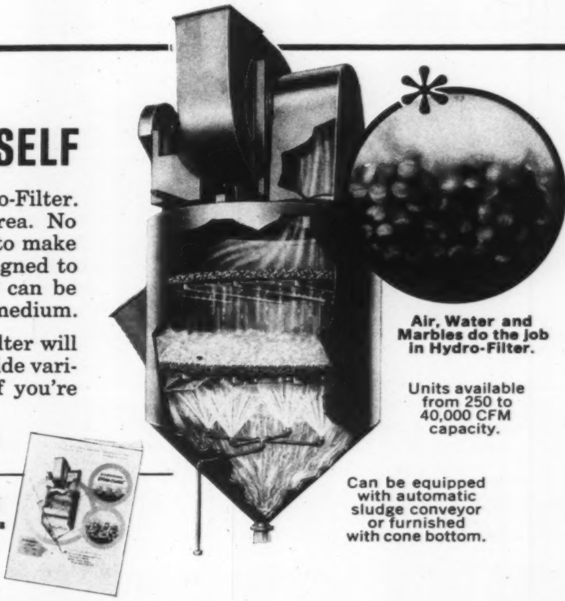

Air, Water and Marbles do the job in Hydro-Filter.

Units available from 250 to 40,000 CFM capacity.

Can be equipped with automatic sludge conveyor or furnished with cone bottom.

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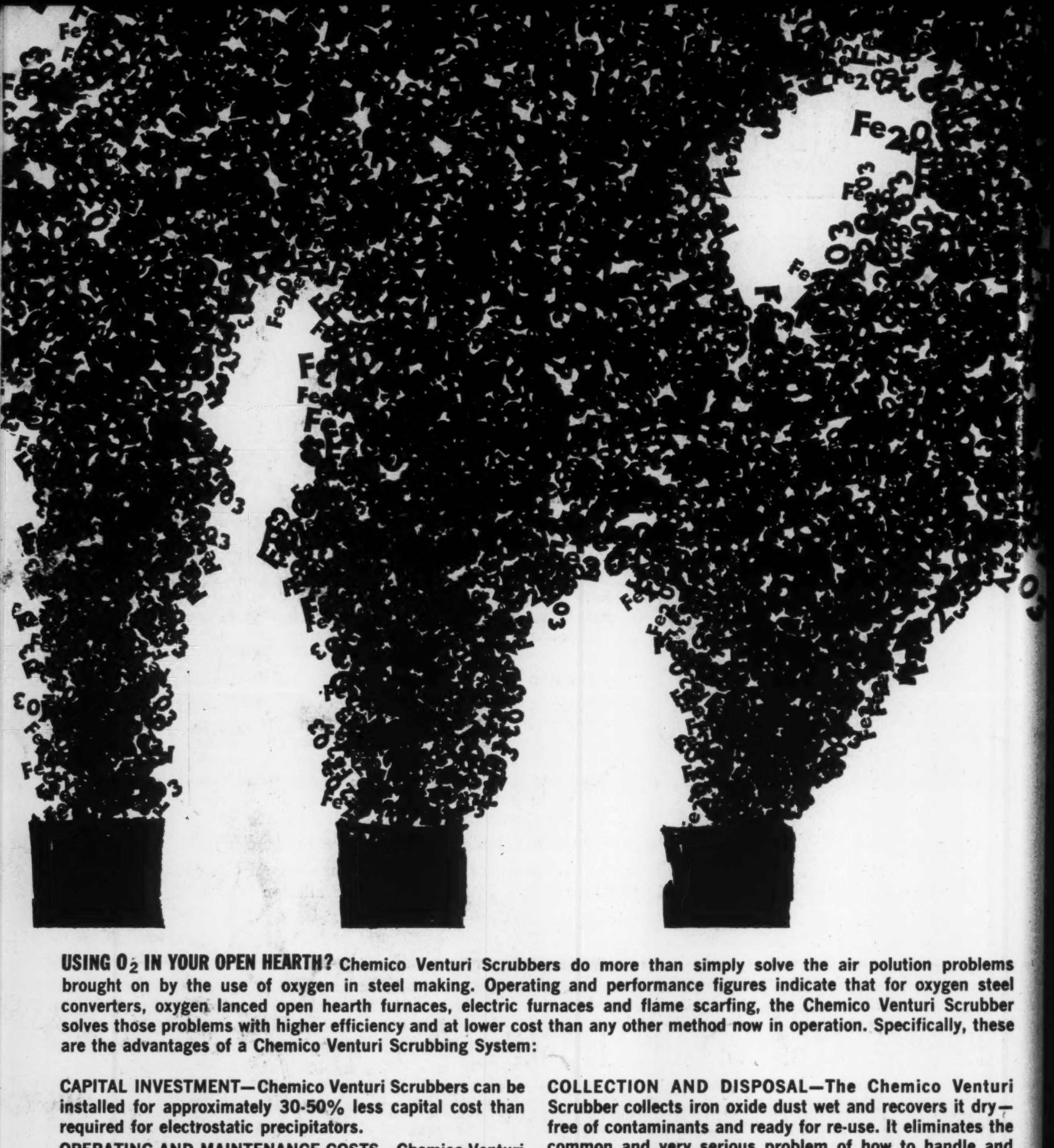

USING O$_2$ IN YOUR OPEN HEARTH? Chemico Venturi Scrubbers do more than simply solve the air polution problems brought on by the use of oxygen in steel making. Operating and performance figures indicate that for oxygen steel converters, oxygen lanced open hearth furnaces, electric furnaces and flame scarfing, the Chemico Venturi Scrubber solves those problems with higher efficiency and at lower cost than any other method now in operation. Specifically, these are the advantages of a Chemico Venturi Scrubbing System:

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OPERATING AND MAINTENANCE COSTS—Chemico Venturi Scrubbers require so little maintenance and manpower, that over-all operating costs are dramatically lower than for other methods, even though power requirements may sometimes be slightly higher.

CONSISTENT PERFORMANCE—The Chemico Venturi Scrubber attains maximum cleaning efficiency at start-up. This peak efficiency is not decreased by subsequent changes in the gas flow or other variations in process conditions.

COLLECTION AND DISPOSAL—The Chemico Venturi Scrubber collects iron oxide dust wet and recovers it dry—free of contaminants and ready for re-use. It eliminates the common and very serious problem of how to handle and dispose of dry dust collected in an electrostatic precipitator.

WATER REQUIREMENTS—The Chemico closed cycle scrubbing process eliminates water disposal problems and cuts make-up water requirements to a minimum. Normally, no more than 50-100 GPM is needed.

PROCESS FLEXIBILITY—Adjustable Venturi throat permits automatic control of furnace draft while maintaining full cleaning efficiency.

If you are considering the installation of gas cleaning equipment, a Chemico representative would be pleased to discuss performance and cost figures with you. Chemico handles the complete job:

PLANNING—DESIGN—ENGINEERING—CONSTRUCTION and START-UP.

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